FORESTRY

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Edited by R. W. V. PALMER

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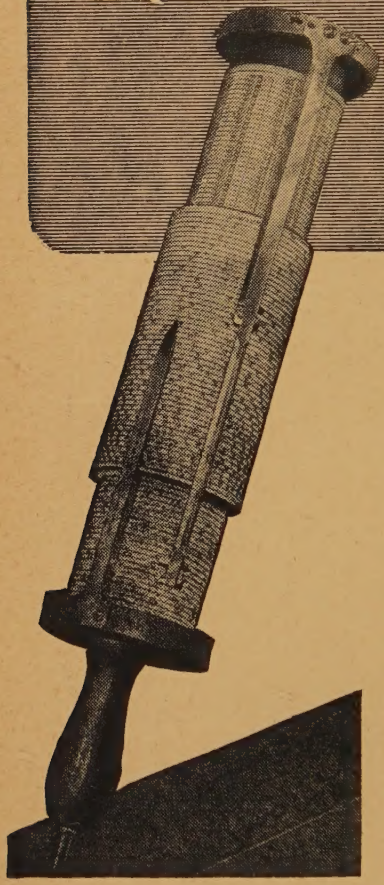

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SOCIETY OF FORESTERS OF GREAT BRITAIN

THIS SOCIETY was formed at Aberdeen in 1925 and adopted its first Constitution at Oxford in 1926. This has been modified several times and the present Constitution became operative in December 1947.

The object of the Society is to advance and spread in Great Britain the knowledge of technical forestry in all its aspects.

The activities include the publication of the journal, the holding of meetings, conferences, and excursions, and the awarding of a medal.

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THE IMPORTANCE OF FORESTRY is being realized more and more in Great Britain. The number of foresters is increasing steadily, and a forestry profession is gradually being built up. It is intended that this Society should be representative of the profession. Those who are not engaged in the practice of forestry or the allied sciences are cordially invited to join the Society as Ordinary Members.

THE SOCIETY'S JOURNAL, called *Forestry*, is usually published twice a year, in June and December. It provides a means for the publication of the results of practice and research both in the growing of timber and in its utilization, including such basic sciences as forest physiology and ecology, forest soils, wood structure, and timber physics, and allied sciences such as forest entomology and forest mycology.

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SOCIETY'S MEDAL. This may be awarded by the Society to any individual who has rendered eminent services to British forestry. Proposals for the award have to be made in the first instance to the Council by a Member of the Council. The regulations for the award will be found in Vol. xx, pp. 80, 81, and in Rule 11.

DISTRIBUTION OF THE SESSILE OAK IN THE NEW FOREST, HAMPSHIRE

By M. L. ANDERSON

INTRODUCTION.

OAK was formerly and for centuries our most important forest tree and it has been the subject of cultivation for centuries. This fact is often apt to be overlooked by ecologists and others, who have tended to ignore to what extent oak and, indeed, other tree-species have been artificially spread in these islands by man. As a result of many and widespread observations over the greater part of the British Isles and of a very comprehensive examination of available literature, I have been driven to the conclusion that everything points to the non-indigenity of the pedunculate oak (*Quercus robur* L.) in these islands, in distinction to the sessile oak (*Q. petraea* Liebe), which is certainly a native species. Never having visited the New Forest prior to 1947, I naturally wondered in what way that opinion would be affected by the conditions prevailing and evidence available there.

During the course of five periods of residence at Lyndhurst in the years 1949, 1950, and 1951, each extending into weeks, I have been able to make a very thorough examination of almost every part of the New Forest, with the main object of determining the present-day distribution of the two main species of oak to be found there, i.e. of the sessile and pedunculate oaks, in order to see to what extent this would affect the hypothesis just mentioned. The study has produced much interesting information, the publication of which may prove of value to future generations of foresters, whatever conclusions they may draw from the data.

METHOD OF SURVEY.

The method of survey is an extremely simple if time-consuming one. It merely consists in the traversing as thoroughly as possible of every wood or inclosure in the forest in order to establish whether and to what extent sessile oak is present in the stands. The reliability of this procedure depends, of course, in the first place, on the ability of the observer to identify the two species. This is dealt with below. In the second place, the value of the estimate of abundance of the species, unsupported as it is in most cases by quantitative data, again depends on the competence of the observer. I leave the results to speak for themselves on this point, merely adding that this survey could never have been completed if some elaborate system of sampling technique had been insisted on. Nearly every wood or piece of wood in the forest has been visited at least once, some important areas, twice, thrice, or even oftener, the later visits usually resulting in new discoveries.

For orientation, location, and recording a set of 6-inch maps of the 1869–70 Ordnance Survey of the forest were used, without which the task would have been impossible. Field notes were written up in the evening after each excursion.

Unfortunately it was not possible to do more than gather a fleeting impression of soil conditions, but it is hoped that the results obtained may serve as a guide for future more intensive soil and site studies.

IDENTIFICATION OF THE SPECIES.

Considerable experience in recognizing the more striking features of the sessile oak, without having to resort to the obtaining of specimens of shoots, twigs, leaves, and fruits, is necessary if a survey on this scale is not to be too time-consuming and if identification is to be reasonably reliable. After more than 10 years of fairly constant practice in the recognition of the two species of oak in the open, I feel that I can claim to be one of the best instruments available at the moment for this special purpose. Fortunately, during the late summer and early autumn, when the greater part of this survey was made, the general appearance of the foliage and crown of the sessile oak, when looked at from below, is sufficiently distinctive to enable it to be recognized with relative ease and certainty, more especially when specimens of the pedunculate oak are at hand for comparison. Stands of pure sessile oak present no difficulty, but it is sometimes rather difficult to determine at a glance whether certain individuals of the pedunculate oak are of that species or not. In only one instance, however, in this forest has it been necessary to resort to the expedient of regarding certain trees as hybrids between the two species. Most doubtful cases have, when more closely examined, turned out not to be sessile oaks, and therefore have not been recorded.

Some of the survey was done during the early spring months, at which time the safest means of establishing the presence of sessile oak in a stand is to examine the fallen leaves. Where leaves of the sessile species are found on the ground it is not usually difficult thereafter to locate the trees whence they have come.

If any reader doubts the value of the procedure just outlined, the information given below is sufficiently detailed to enable him to verify the statements made in the forest itself.

RESULTS OF THE SURVEY.

The presentation of the results of this survey might have been made in a number of different ways. In the end I decided to deal with the information, so far as possible, on the basis of age of stand. In doing so I start off with the assumption that originally the whole forest consisted of sessile oakwood, and, indeed, the site and soil conditions over the greater part of the forest support such a view. I assume that this oakwood was heavily exploited throughout the centuries in the usual way, especially on the better low-lying sites, nearest to the sea-board, but that remnants of the original sessile oakwood are most likely to persist in the more remote parts of the forest, outside recorded inclosures. By recorded inclosures I mean inclosures given on the 1875 amended version of Couchman's 1849 map (6). I therefore deal first of all with (A) uninclosed woods containing some proportion of sessile oak. I next assume that the earlier plantations made prior to 1700, that is, from as early as 1530 at least, consisting mainly of oak and beech, were established on relatively good, cleared ground, not required for farming, nearest to

the sea-board, i.e. to the market. I next deal therefore with (B), uninclosed woods, containing very old trees, but no sessile oak. I do not regard beech as being indigenous here. In spite of the numerous natural seedlings of this species, the older trees and stands never have a healthy appearance, certainly not on the poorer sites where there are clear signs of soil deterioration under this species. Here, as in many other parts of the country, old beech and pedunculate oak in mixture—not a mixture of natural occurrence—is strong evidence of the artificial introduction of both these trees. The various inclosures, (C), are next dealt with in eight groups, as follows: (1) inclosures reputed to have been made in 1700 and 1756; (2) inclosures made in 1775; (3) those made in the period from 1808 to 1820; (4) inclosures made in the year 1829; (5) those made in the period from 1843 to 1853; (6) those made in the period from 1859 to 1862; (7) those made from 1864 to 1870, and lastly, (8), inclosures the date of which I have not been able to determine, but which seem to be relatively recent. Finally, (D), I deal with uninclosed woods, containing no sessile oak, which are of relatively recent age, in which pedunculate oak predominates, and which have obviously arisen naturally and avificially (1) that is, by the action of birds in spreading the seed, in areas with sufficient thorns, &c., to enable the young trees to establish themselves. The information which follows is thus presented in the order A to D. Detailed map references where given refer to the 6-inch maps already mentioned.

A. Uninclosed Areas with a Proportion of Sessile Oak

These are numbered from I to XXXVI in roman numerals on the key map.

I. *Anses Wood.* Lying between S. Bentley and Holly Hatch Inclosures, this area consists largely of second-generation pedunculate oak, but there is a considerable number of sessile oak on the upper, southern margin.

II. *Bignell Wood.* This extensive area has not been thoroughly examined in spite of two traverses. The ground is rather poor and the stand consists of scattered pedunculate oak and beech, having the appearance of second- or third-generation trees. A group of six medium-sized sessile oaks were located immediately west of the winding stream running north of the 'p' of 'copse' in 'Piper's Copse'—south-west of Canterton Green. These may either have originated from older mother trees on the spot or from seed borne by birds from more westerly areas. The group is an outlier of the main block of sessile oak.

III. *Bramshaw Wood.* Walking uphill from the Cadnam–Salisbury turnpike road towards the south, one finds that the old stand consists at first of large pedunculate oak and beech, typical of the old pre-1700 plantations, but that halfway up it changes over to sessile oak and beech with some very large trees of the former. This is almost certainly the case of a plantation merging into the remains of natural oakwood, as may be seen elsewhere. This is one of the more important remains of the natural sessile oakwood. (See later under XII.)

IV. *Brook Wood.* The extreme eastern, lower-lying area is pedunculate oak, but this passes into a mixture of large sessile oak and beech as one moves westwards and up the slope. This forms part of the main block of sessile oakwood, but it

seems that the beech and pedunculate oak have been introduced on the lower slopes after removal of the original sessile oak.

V. *Castle Malwood.* Immediately east of the road leading from the Romsey 8 milestone to the Rufus's stone, there is a very narrow fringe of rather short sessile oak just below the crest of the slope. Below this towards Cadnam the wood consists of pedunculate oak and beech, not of the oldest type. This fringe would seem to be a remnant of the former sessile oakwood, and north of the main road from here to Stony Cross there are a few small scattered sessile oaks.

VI. *Clayhill Heath.* In a triangular area east of the Lyndhurst–Brockenhurst road there are two groups of nice middle-aged sessile oaks in a small stand of old pedunculate oak and beech, with a dense holly underwood. The soil is a heavy clay. This is one of the best examples of natural seeding of sessile oak and of the recovery of ground by that species. Scattered groups of younger sessile oak and beech regeneration extend across the ride to the north-east. These young groups have probably arisen from seed carried from Whitley Wood or Park Ground Inclosure.

VII. *West of Copse of Linwood Inclosure.* The fringe of wood between this inclosure and the Fritham–Lyndhurst road contains several sessile oaks towards the north end. Moving round to the south an area of pedunculate oak is met with, but for an occasional sessile oak on the eastern margin. It is suggested that the pedunculate oak have seeded from trees planted at Fritham Lodge into what is a fringe of former sessile oakwood. (See later under Copse of Linwood Inclosure 13.)

VIII. *Crow's Nest Wood.* This area is on the extreme north boundary of the forest and is mainly young and middle-aged pedunculate oak, but there are also a few sessile oaks in a detached higher-lying portion.

IX. *Frame Wood.* The area of this wood is now restricted between the inclosure fences of Frame Heath (1852) and Hawkhill (1870) Inclosures. It consists almost entirely of open old pedunculate oak with a few beech. There are only a few sessile oaks in the north-east corner, where the wood links up with Hawkhill (q.v. XXVIII). The crowns of the pedunculate oak are very dilapidated as a rule, but there are occasional good trees.

X. *Fritham.* Most of the hedgerow trees around Fritham are pedunculate oaks, but there are at least two sessile oaks in the hedgerow running north to south between Fritham Farm and Fritham House.

XI. *Gibbet Wood.* This is an important small area lying south of Salisbury Trench and east of Copse of Linwood Inclosure, which has never been inclosed but lies in such a position that it must have been almost isolated and little disturbed. No beech are present in the pure sessile oak stand. I take this to be a true remnant of the original sessile oakwood on the heavier low-lying soil types. The trees are mostly very large and vigorous. There was a fair crop of acorns on some of the trees in 1948, none in 1949, and a few in 1950, mostly on shorter trees. This important area should be preserved as it probably represents the type of stand which formerly occurred over much of Salisbury Trench.

XII. *Great Wood.* This quite extensive area consists of open old sessile oak with some beech and is obviously a remnant of a larger area of sessile oakwood,

linking up with the fringe in Bramshaw Wood. Between these two woods on a tongue of woodland projecting to the west on a very exposed margin there is a very vigorous and healthy-crowned sessile oak between Piper's Wait and Black Bush Plain. In holly clumps around it are a few young sessile oak. In Great Wood there were numerous 1-year oak seedlings in 1949 but few acorns that year.

XIII. *Gritnam Wood.* This is evidently an old plantation as it consists mainly of very old beech and pedunculate oak, with middle-aged groups here and there, which have sprung up naturally. These latter are almost all pedunculate oak and beech, except in the immediate vicinity of Brick-kiln Inclosure, where there are occasional very vigorous sessile oaks in some of the groups near the north end of that inclosure, in which there is a mature stand of that species. There seems no doubt that these sessile oaks have come from seed carried by birds from Brick-kiln Inclosure mother-trees. (Cf. Whitley Wood, XXXV.)

XIV. *Hardus Green.* Here the stand consists mostly of youngish beech and pedunculate oak, but to the south-east of Shave Green one rather bent sessile oak was found amidst holly, and to the west, beyond an area of vigorous but badly-shaped old beech with some pedunculate oak, on the margin of the wood, north-east of Eugene Cottage, there is a group of six large old sessile oaks, with a seventh large isolated tree just east of them. There are also three or four smaller younger trees, and one detached younger tree to the west of the 'H' in 'Hardus'. These latter have presumably seeded from the older trees, which are evidently a remnant of original sessile oakwood, and important as they fill rather a large gap in the picture.

XV. *North of Highland Water Inclosure.* Beside the stream which flows into the northern margin of this inclosure and on the east side of the stream there are two large old oaks, the one nearest the fence being pedunculate and the one farther off sessile. The oaks within the inclosure here are pedunculate. This sessile oak forms a link between Mogshade Hill (XXI) and Puckpits Inclosure (4).

XVI. *King's Hat.* This is one of the most important remnants of sessile oak-wood in the forest. Like Gibbet Wood it lies in an angle between two inclosures—Parkhill and Ramnor. Its importance lies in its position as a link between the main high-lying northern blocks of sessile oakwood and the area at Hawkhill. In a belt of at least 150 yards in length along the south edge of Parkhill Inclosure, on heavy clay soil similar to that in Red Shoot Wood (XXV) and Gibbet Wood, there is a very old stand of large sessile oak nearly pure but with occasional beech and pedunculate oak. The underwood is holly with some field maple and the soil is mull. The sessile oak thin out eastwards towards a hollow while the pedunculate oak increases, and there is a good deal of second-generation pedunculate oak around old lawns. Between this old wood and the Parkhill Inclosure are some second-generation beech and sessile oak groups and also still younger groups and seedlings of both species of oak under some Scots pines. Parts of the stand have a nice irregular group structure.

Towards Ramnor Inclosure there is a higher proportion of old pedunculate oak and beech, but still a good proportion of sessile oak. Near that inclosure fence are three very large sessile oak and one old beech. There are also considerable

belts of second-generation beech with a few scattered pedunculate oak and sessile oak. In the re-entrant there are a few sessile oak with pedunculate oak and Scots pine.

Holland's Wood merges into King's Hat, and my impression is that the sessile oak are older than the pedunculate oak and beech and that the former were probably in existence when Holland's Wood was planted. The soil conditions are specially interesting.

XVII. *Near Little Clumber's Inclosure.* In the triangle between this inclosure and Alderidge Hill Inclosure there is a stand of old Scots pine containing a group of rather young sessile oaks. These may have originated from seed brought in from Rhinefield Inclosure.

XVIII. *Near Long Beech Inclosure.* Two isolated trees between the western edge of this inclosure and the road are sessile oaks—relatively aged, forming a link in the fringe of original oakwood.

XIX. *Lucy Hill.* This small area is an interesting island of sessile oak between two of the western inclosures, Burley New and Oakley, in the first of which the main crop is almost entirely pedunculate oak and in the second a varying mixture of the two species. These trees on Lucy Hill consist of several dense groups of from 12 to 20 trees each, mostly of average size, but some are quite large. The proportion of pedunculate oak is very small and they are usually smaller trees. On the top of the hill isolated by a wide open belt is one large pedunculate oak. Scattered sessile oaks of middle age occur on a ridge running south to Burley Cottage, and there is a scattered group of five rather older trees beside the houses west of Lucy Hill. The Lucy Hill sessile oaks have full vigorous crowns although exposed to the west. These trees may have originated from older trees in the adjoining Burley New Inclosure, but it is much more likely that they derived from older sessile oaks on the hill itself, in view of the remnants of sessile oak still existing on its west flank. This western outlier is a very important one, in view of the general absence of sessile oak in the woods to the west of this area.

XX. *Lyndhurst Hill.* This is obviously one of the pre-1700 plantations, consisting of very old pedunculate oak and beech, but also with scattered old sessile oaks. An extraordinary feature of the wood is the occurrence of numerous groups of natural sessile oak, beech, and occasional Turkey oak—up to possibly 100 years of age. This seems to be a case where the sessile oak has beaten the pedunculate oak in competition with beech under the presumably shaded conditions of the old stand. The finest examples of the sessile oak groups are in the moist hollow over the Headon Beds formation beside the main Bournemouth road, east of Cut Walk and west of Cufnell's, but good groups extend almost all round the hill. There are two specially fine sessile oaks just north of Swan Green cricket pitch. The vigour and form of most of these sessile oaks and the success with which they have invaded pedunculate oak-beech mixture show what sessile oak will do on the better soils. See also Whitley Wood (XXXV). The Turkey oak have probably seeded from old trees in Cufnell's, but there is no present nearby source of sessile acorns other than the scattered old trees on the hill itself.

XXI. *Mogshade Hill.* Between Fritham Cross and Mogshade Hill (310 feet),

about 200 yards north of Highland Water Inclosure, is a group of three large old sessile oaks and six smaller ones with a few old yews. These trees are on a very meagre soil over plateau gravel and are beginning to look decrepit, the stems being decayed. They carried a good deal of seed both in 1949 and 1950 and one or two very young seedlings were seen in the *Calluna*. This is an important link in the high sessile oakwood fringe and a good example of the last stage before its complete disappearance.

XXII. *Near Perry Wood*. One young sessile oak was found outside the western edge of the south block of Perry Wood Inclosure, west of the 'P' in 'Perry'.

XXIII. *Pinnick Wood*. This wood overlies Barton Clay and consists of rather scattered, short pedunculate oak with quite a dense stand of younger second- and third-generation pedunculate oak. Towards the south-west side, north of Marrowbones Hill, five sessile oaks were found growing on the clay, two of which were very old and seemed to have grown from stools. Some of the pedunculate oak were equally large.

XXIV. *Queen Wood North*. This is known to have been an old inclosure and one of the earlier plantations on a good site. It consists of very heavy beech and pedunculate oak of the usual type with a dense holly understory on a mull soil, but on the north-west fringe there is a large sessile oak and two young ones in a clump of holly. A group of three old sessile oaks and two isolated old sessile oaks, one near the centre of the wood, were also located. This would seem to show that when the inclosure was made, a few sessile oaks were taken in on the higher ground. Younger pedunculate oaks occur in the vicinity in hedges, &c. These are vigorous and may have originated from the old trees in this wood. (See also Bentley Woods, N. and S (1. and 2.).)

XXV. *Red Shoot Wood*. This large uninclosed area lying towards the western side of the forest is in some ways the most interesting and important remnant of the original sessile oakwood. Like Gibbet Wood, King's Hat, and Hawkhill (XXVIII) it lies in a remote part of the forest hemmed in by inclosures—in this case by Appleslade Inclosure, Great Linford and Roe Wood Inclosures. At its north end and due east of the eastern bend of Appleslade Inclosure there are some very large, very old sessile oaks, including at least two with extremely large leaves. The soil is a heavy one over Barton Clay, and there are also a few scattered young sessile oaks growing amongst the more abundant young pedunculate oaks, all plainly of natural origin.

The southern extension of Red Shoot Wood, lying north-west of Great Linford Inclosure, is, however, nearly pure sessile oak. The trees are very large but rather twisted, again growing on heavy clay, and between them are clumps of a younger generation of mixed sessile and pedunculate oaks in the proportion of about three to one, but few are very straight. There is one particularly strong and vigorous old sessile oak. The exposed margin of this wood contrasts markedly with that of Great Linford Inclosure to the south-west. There the castanea are much blasted and the pedunculate oak have extremely thin crowns. The superior resistance of the sessile oak to exposure is very plain. There is quite a considerable area of this nearly pure old sessile oakwood, but the proportion of pedunculate

oak increases to the north and these are obviously younger. The soil is a true mull with plenty of worm-castings and the vegetation is a rich one, including *Primula*. There is a good deal of young ash in places, but only one group of middle-aged ash was seen. One young beech seedling and one middle-aged beech were found, but there are no old beech in the wood. There is a fringe of birch on the south-west margin, a rare tree in the forest. In 1950 there was a heavy crop of acorns on these oaks, but the area is open to the exercise of rights of pannage!

This is one of the few places in the forest with two quite distinct generations of sessile oak, apart from Salisbury Trench, which has been artificially treated. It should be preserved and inclosed, and steps taken to stop the intrusion of pedunculate oak, which has been going on for many years.

XXVI. *Ringwood Bushes.* In the triangle of wood adjoining the fields south-west of Robin's Bush farm there is a clump of oaks, of which one large tree is sessile and one younger tree in holly scrub. This makes a link with the Hardus Green group. All the oak from there up to Ringwood ford are pedunculate second-generation oak in alder scrub. One rather young sessile oak of unusual type stands just within Highland Water fence west of the ford.

XXVII. *Ringwood Ford Bottom.* Above the 'T' of 'Minster' there is a group of old beech and in the holly to the east side of it one rather young sessile oak and one pedunculate. To the north side is one very young Turkey oak.

XXVIII. *Hawkhill.* The area west of Askin Gutter consists of mixed beech and pedunculate oak in the lower ground to the north, but, as one moves south-west up the hill, sessile oak comes in—many of large size—and the proportion increases until near the Frame Heath Inclosure fence it becomes almost pure old sessile oak in irregular groups, with some beech. There is a considerable area of second-generation beech, sessile oak, and pedunculate oak on the south-east slope of the hill in dense canopy. Groups of old sessile oaks occur of rather poor type, linking up with the Frame Wood area (q.v. IX). The soil is very heavy in places. It may be of some importance that this area is just inside the boundary of Lady Cross Walk and that to the north in the next walk no sessile oak remain. There may at one time have been different policies operating in the two walks. The importance of this area is its being the most south-easterly block of relict old sessile oakwood and in its remote location.

XXIX. *Spreading Oak.* Between Winding Stonard (XXXVI) and Fritham Cross is a solitary old sessile oak making a link between Mogshade Hill and the Bentley's.

XXX. *Stonard Wood.* Above and east of Puckpits Inclosure (4) along the track from point 328 to point 352 there are some ten sessile oaks, some old and some younger. These lead eastwards to Stonard Wood. Approached from the south-east this wood appears as a very striking example of really old sessile oakwood, with only one old pedunculate oak at the east corner and some younger beech. There is a ring of holly with middle-aged sessile oak to the north-east and under one wide-crowned veteran, numerous quite young seedlings. The old trees are tall and imposing in spite of the gravelly soil, but some of the crowns are beginning to thin and the wood is becoming rather open. There are many holly seedlings.

There are about twenty really large old trees and this, too, is an area which should be preserved. It is an important relic of the high-lying sessile oakwood on lighter soil. It links with Puckpits, Hardus Green, and Long Beech Inclosure.

XXXI. *Stricknage Wood.* This is mostly beech and pedunculate oak of relatively young age. It was not completely traversed, but one large sessile oak stands on the edge of the wood due north of the Compton Arms Hotel to form a link between Long Beech Inclosure and Castle Malwood.

XXXII. *Stubbs Wood.* Entering from Pennerley Lodge, near which there is the usual type of old plantation of large beech and pedunculate oak with holly understory with groups of younger trees, as one approaches the centre of the wood one finds two very old and very large sessile oaks standing together. Further examination would probably show that the number of sessile oaks would increase towards the Hawkhill groups.

XXXIII. *Suburbs Wood.* This link between S. Bentley and N. Bentley contains both sessile and pedunculate oaks, not markedly different in age nor very old. On high ground in the south-east projection is pure beech. There is a group of five sessile oak just south of the 'burbs' of 'Suburbs'.

XXXIV. *Tom Pook's Hill.* This area consists largely of second-generation pedunculate oak, nearly pure on the lower ground but passing into a mixture of the two oak species on the higher ground in conformity with the position in Long Beech Inclosure.

XXXV. *Whitley Wood.* On the lower ground of this extensive area, to the west of the Brockenhurst road is a mixture of very old pedunculate oak and beech, with some sessile oaks. Just as on Lyndhurst Hill (XX), middle-aged groups of oak and beech occur, and in the vicinity of Park Ground Inclosure at the north end of the wood, these groups consist almost entirely of sessile oak and are unusually vigorous. The old sessile oaks and groups of middle-aged trees increase towards the main road on the rising ground, but the farther south one goes the more pedunculate oak occur (see also Clayhill Heath, VI). It would seem that the Park Ground sessile oaks have furnished seeds for most of these groups and it is interesting that the sessile species—when vigorous mother-trees are present—can more than hold its own against both pedunculate oak and beech. One very large pedunculate oak was seen on the low ground where soil conditions are good.

XXXVI. *Winding Stonard.* At the tenth milestone between Romsey and Ringwood, north of the road, there are a few very large old sessile oaks, one probably having the stoutest girth in the forest for this species. The underwood is dense holly and yew and the young oak trees throughout the area are all sessile. This area links up Ocknell Inclosure and Mogshade Hill.

Observations on A, the Uninclosed Areas with Sessile Oak Present.

The thirty-six items listed above may be conveniently grouped into three groups, as follows: (*a*) items I, III, IV, V, VII, VIII, X, XI, XII, XIV, XV, XVIII, XXI, XXIII, XXIV, XXV, XXVI, XXVII, XXIX, XXX, XXXI, XXXIII, XXXIV, and XXXVI. These together furnish indisputable evidence that, until relatively recent times, there must have been an extensive mass of

natural sessile oakwood concentrated on and around the high ground in the northern part of the New Forest. Ignoring for the moment the additional evidence from inclosures which strengthens this view, the examples of old woodland in Red Shoot Wood, Bramshaw Wood, Great Wood, Brook Wood, Gibbet Wood, and Stonard Wood, the fringes of sessile oak above Anses Wood, Crow's Nest Wood, Copse of Linwood, Long Beech Inclosure, Tom Pook's Hill, Stricknage Wood, Castle Malwood, and Hardus Green, and the fragments of old sessile woodland in Winding Stonard, Mogshade Hill, by Highland Water Inclosure, in Queen North Wood, Ringwood Bushes, and Pinnick Wood all point clearly to there having at one time been an almost continuous area of sessile woodland linking up these occurrences and embracing portions now included within N. and S. Bentley Inclosures, Salisbury Trench, Raven's Nest, Long Beech, King's Garn Gutter, Puckpits Holly Hatch, and Roe Wood Inclosures. These areas, it should be observed, lie in that part of the forest most remote from the sea-board and thus where one would expect the most important remnants of original natural woodland to be.

A matter of much interest is that two, at least, of the most striking examples in the list occur on heavy clay soils, namely Red Shoot Wood and Gibbet Wood, which seems to me to show that the sessile oakwood was not originally confined to the lighter, drier soils. I had already formed the opinion that, in fact, the heavier most vigorous stands of sessile oakwood were originally to be found on the heavier soils all over the country, and that it was from these, which happen to be most accessible as a rule, that the heaviest and earliest fellings were made. The relative scarcity, even absence, of beech in most of the areas in this list is also a point to be noted, especially in Red Shoot Wood and Gibbet Wood.

(*b*) Items IX, XVI, XIX, XX, XXVIII, XXXII, and XXXV. These areas lie to the south of those listed under (*a*) and thus in a part of the forest more accessible to markets. Nevertheless, they furnish evidence which shows that here too the original natural woodland could have been sessile oakwood. This applies more especially to the Hawkhill, Stubbs Wood, Whitley Wood, Frame Wood, and King's Hat areas, especially the last named, which is a very striking example of old woodland, although no longer consisting of pure sessile oak. The Lyndhurst Hill area is of more particular interest as it shows that sessile oak can readily reconquer lost ground, as do the groups in Whitley Wood. The Lucy Hill area suggests a sort of rear-guard of sessile oakwood representing all that is left on the westward side of the forest of possibly very extensive areas which were exploited from the Avon Valley.

(*c*) Items II, VI, XIII, XVII, and XXII. These do not refer to older trees, but they indicate how successfully the sessile oak can recover lost ground wherever sufficient suitable seed-trees occur and conditions of soil and soil-cover are suitable. The Clayhill Heath and Little Clumber's areas are of special interest in this connexion.

To sum up, we can say (i) that the survey has disclosed remnants of former sessile oakwood which show unmistakably that in the northern parts of the forest there was formerly a very wide expanse of that type of woodland, and which suggest

that similar sessile oakwood also occurred in the southern parts of the forest. This disproves Burtt Davy's suggestion (2) and Smith's view (9) that the sessile oak was probably introduced relatively recently into the forest, a view which might be justified from inspection of recent inclosures only, and (ii) that it has also disclosed the capacity of sessile oak for recovery of lost ground, even on the heavy soils, provided conditions are suitable.

B. Uninclosed Areas Containing Very Old Trees, but no Sessile Oak

These areas are lettered A to Z on the key-map. The following descriptive notes are rather brief, as the main objective when inspecting the woods was to determine whether sessile oak was present or not.

A. *Ashurst Wood.* This rather extensive area is centred on a gravel ridge—the same one which runs through Church Place Inclosure. The ridge is covered with very decadent old beech and the soil is a distinct mor. Scattered through the wood are old pedunculate oaks with very poor, broken crowns. All the oaks between Ashurst and Lodgehill and on the fringe of Mallard Wood are pedunculate. The bulk of this site is not a pedunculate oak site and this is one of the least successful of the old beech/oak plantations. Around the edges of the older wood is the usual fringe of younger pedunculate oak.

B. *Bignell Wood, Rockram Wood, and around Cadnam.* See under A, item II. The small group of youngish sessile oak in the wood scarcely justifies the exclusion of this large area from class B. In these woods beech and pedunculate oak occur, but they are not of the oldest generation.

C. *Berry Wood.* Resembles Ridley Wood (S), but the trees are generally shorter and the proportion of pedunculate oak as compared with beech is higher.

D. *Bolderwood Hill.* The wood between this hill and Holmshill Inclosure is old and on unusually good ground. The beech are tall and sometimes have very good form. There is one very fine stem of pedunculate oak, which are few in number, near the fence angle south-west of 'Holm'. Groups of second-generation beech and pedunculate oak occur and the strain of the latter seems to be a better one than usual, which may be a soil effect. The area has affinities with Mark Ash.

E. *Bratley Wood.* An area west of Bratley Inclosure seems to be part of the older Bratley Wood. It contains large old pedunculate oak and beech and there is an area of pure old beech north of the main road and west of Shufter's Inclosure. This is not a site suited for pedunculate oak and beech.

F. *Burley Outer Rails.* All pedunculate oak on the western side but not fully traversed.

G. *Burley Street and around Burley.* All oaks are pedunculate and often quite vigorous and large on the better soils. High Croft Wood, however, is an excellent example of the inability of pedunculate oak to withstand exposure on light gravelly soil. Oddly enough, there are no sessile oaks on Durmast Hill.

H. *Buskett's Wood.* This resembles Rush-pole Wood (U), being very old pedunculate oak and beech. Some of the former are large healthy trees, but the beech are becoming decadent. The inclination of some of the stems suggests that they originated in clumps of holly, thorn, &c.

I. *Denny Wait.* This is an old stand of heavy beech and pedunculate oak, with some very large specimens of both, but there are signs of soil degradation under the beech. Nevertheless, there is a considerable expanse of mull soil in this wood. Only one old crooked sessile oak was found, about 100 yards north-east of Little Holmshill Inclosure beside a small netted plot. A fairly widespread search failed to locate any others and the single tree does not seem to justify putting the whole wood in class A. This is one of the few woods with sycamore regeneration.

J. *Denny Wood.* Amongst the old pedunculate oak in the triangle just west of Denny Lodge and outside the inclosure one mature sessile oak occurs. This does not seem to be a very old tree and, being near the lodge, might have originated artificially.

K. *Eyeworth Wood.* This is the usual type of old plantation consisting of beech and pedunculate oak. On the lower slopes it is good with large specimens, especially of beech, but much poorer in the centre and on the higher ridges. The beech there are decadent and the soil probably degraded. In places the holly is very dense and groups of second-generation beech and oak occur. One ash was seen. Within the re-entrant around the 'Eye' of 'Eyeworth' is a hollow with really fine, very large beech and a few pedunculate oak.

L. *Fox Hill.* Almost all old beech, but one old pedunculate oak occurs. Some evidence of old banks of former fence-lines around this area. The beech are now decadent and the soil is degraded.

L[1]. *Hincheslea Wood.* Though lying within the forest area it is privately owned. Clearly this is an old planted wood of beech and oak, most of the latter having been cut out, leaving some very large beech. Throughout the scattered second-generation oak only one sessile oak was found about 100 yards east-south-east of the word 'Wood'. This may have originated avificially from Wilverley Inclosure, but its age is somewhere near the hundred.

M. *Holland's Wood.* This extensive area has not been completely examined, but, seen from the road and in the southern part, it is all pedunculate oak, not of the oldest class. The soil is generally of a heavy type and unsuited for beech. The wood merges into Clayhill Heath and King's Hat areas where sessile oak occurs.

N. *Iron's Well Wood.* This is the usual type of old plantation, but the soil is a good mull. The stand is mixed beech and pedunculate oak with a heavy understory of holly and yew. There is almost a complete holly canopy. The pedunculate oak, some of which have very large boles, are of the usual branched type with shattered crowns. Gaps are appearing in the wood. One patch of seedling beech with a few oaks occurs. In the hollow towards the well the oak and beech are exceptionally tall. On a gravel ridge south of Eyeworth Lodge is a single isolated vigorous pedunculate oak. There is the usual fringe of younger pedunculate oak north-east of the wood and an even younger generation scattered in distant bushes to the north.

O. *Knightwood–Vinney Ridge Area.* Outside the inclosures groups of old beech and pedunculate oak occur, presumably remains of former plantations.

P. *Little Fox Hill.* As for Fox Hill, but with no oak.

Q. *Mark Ash Wood.* Very large and old pedunculate oak and beech, very much over-mature and very typical of these older plantations. No sessile oaks were found in the wood, but there are groups of younger trees of beech and pedunculate oak.

R. *Matley Wood.* Old pedunculate oak with castanea and a few beech and lime. The oaks are large, but their crowns are now much shattered. There are large trees with spreading crowns on the margins.

S. *Ridley Wood.* Typical old beech and pedunculate oak but very few oak. Carefully examined, but no sessile oaks were seen. The beech are now beginning to go off, although for the most part the soil is good. There is the usual fringe of younger pedunculate oak on the margin.

T. *Running Hill.* Around Castle Malwood—mostly old beech with some pedunculate oaks, one or two of which are large. The ground is good.

U. *Rushpole Wood.* This is an interesting wood, well protected from grazing by Busket's Lawn and Furzy Lawn Inclosures. The very old, mostly stag-headed oak mixed with beech are all pedunculate. There is considerable group regeneration of beech and pedunculate oak in gaps, more especially where old trees have died. These groups make an interesting contrast with those of sessile oak on Lyndhurst Hill and Clayhill Heath and in Whitley Wood. They illustrate well what Evelyn meant by the 'upright oak' and the 'spreading oak'. These groups owe their existence to the presence of holly and to non-interference by man or by grazing animals for some 300 years, being very secluded. The height in the groups varies considerably and some of them might be 70 to 80 years old. The wood is worth a special and careful study. One wonders what would have happened here if seed-trees of sessile oak had been near at hand.

U[1]. *Tantany Wood* (part of). Mixed beech and pedunculate oak with holly underwood of the usual type.

V[1]. *Undersley Wood.* Very open old pedunculate oak and beech, the former being very stag-headed and decrepit. A ring-count of a felled tree gave an age of about 150 years, but, as usual, the trees look much older than they are. (One tall middle-aged Turkey oak occurs and many young seedlings of that species.)

W. *Vereley Wood.* Typical old beech and pedunculate oak—with vestiges of an old inclosure ditch. The usual fringe of younger pedunculate oak. No sessile oaks were seen.

X[1]. *Wick Wood.* Typical old plantation of beech and pedunculate oak, but very few of the latter left and the former are in the last stages of decay. Around it to the west and along the streams youngish pedunculate oak—probably planted with the original Scots pine crop, but some have come up naturally.

Y. *Wood Crates, Allum Green, and Bramble Hill.* Mainly old beech.

Z. *Wooson's Hill.* Mainly groups of old beech.

Observations on B, Uninclosed Areas of Very Old Trees, but with no Sessile Oak.

Apart from items F, G, and V[1], all the areas described above are very similar, except in respect of the present proportion of oak to beech. Where the soil and site are more fertile, the old trees are less decadent, but on the poorer sites both the pedunculate oak and beech suffer from exposure much more than does sessile

oak on similar sites. A feature of the old pedunculate oak is the shattering of the crown with age. Another feature worth noting is the fringe of second-generation oak and beech which usually accompanies these old plantations, when soil conditions and protection are favourable. The protected location of Rushpole Wood has enabled the pedunculate oak to regenerate quite well where the canopy is broken sufficiently to let in enough light.

Some support seems to be desirable for the view held that these areas represent pre-1700 plantations and are not remnants of natural beech/oakwood. For this support I turn to Lascelles, who was in a position to consult the old records. This I have deliberately refrained from doing as I wished to base the survey entirely on evidence existing on the ground. It should be interesting for some future investigator to search the old records for confirmatory evidence, or the contrary, for statements made.

Writing in 1895, Lascelles (3) says:

'Under the head of plantations nothing is included of an earlier date than those which were planted under the Act 9 and 10 William III, that being the first date at which the plantations were enclosed under a Commission . . . there were innumerable plantations made previous to that date, but what is left of them has either been absorbed into more modern plantations, or else is included under the head of "open lands with timber".'

He gives the area of old woods planted prior to the year 1700 and still extant as 4,600 acres.

Then again he says,

'The practice of cultivation seems to have been that of "natural regeneration". . . . In the old days it went by the name of "encoppicing", and the process seems to have been simply to enclose the area by a fence against cattle and deer, and to rely on natural reproduction of the seed from the existing crop of trees to replenish the wood.'

'It does not seem certain whether in Elizabethan days the foresters relied wholly on natural regeneration for their crop, or whether they also did some planting or sowing of seed. As the coppices were brought regularly under cultivation, it seems probable that they did plant or sow, especially in those cases where the woods were farmed out and the tenant had to make as good a profit as he could in a fixed term. It is hardly possible that so dense a wood as is found in Mark Ash could be achieved by the self-sown timber over so large an area, and be all of the same age; such timber would vary somewhat in age, and these woods do not. In the catalogue of the woods made in the year 1565 the expression, in the description of each wood, frequently occurs of "set" with oak or beech, as the case may be; and this seems to indicate that the crop was not wholly natural.'

Again:

'It is clear that the cultivation of the trees and woods of the forest was undertaken some time prior to the reign of Edward IV, say four hundred and fifty years ago. . . . It is our beeches that are the glory of our oldest woods, and it is very unlikely that any of these we now see are of older date than the records of the Exchequer in the time of Elizabeth, at which period the forest was as much under a system of enclosing for planting as ever it has been since.'

Finally, he states (4) that there were records 'to show that planting had been engaged in as far back at least as 1530, and from that date to the middle of the

present century there was more planting and more care given to the trees than there had been since.'

In his book *Thirty-five Years in the New Forest* (1915) (5), chapter xi, he lists some of the woods which were encoppiced and planted before 1700, and the list includes Bratley Wood, Holland's Wood, Mark Ash, Ridley, and Vereley Woods.

The above evidence shows that it was quite possible for all the older beech and pedunculate oak of what I call the first generation of these species to have been planted artificially. The areas selected for planting seem mostly to have been on reasonably good ground, with some exceptions, and it will be seen that they tend to lie near centres of cultivation—around Lyndhurst and to the south and south-east thereof; in the vicinity of Burley and near Fritham, where it is probable that the better stands of original sessile oakwood had been cleared at an early date for the usual reasons.

Contrary to Lascelles's view, it was still possible and indeed, almost certain, that extensive areas of natural sessile oakwood still existed when these plantations were made and that there would as yet be no beech in these woods. It was not, therefore, necessary to assume that oak was planted or sown pure or that the beech was removed artificially, to account for the pure oakwoods in certain parts of the forest.

C (1) Inclosures Reputed to have been made in 1700 and 1756

There are eleven in all, numbered 1 to 11 on the key-map.

1. *Bentley, North.* Unfortunately most of this wood has recently been felled and planted with conifers, but the scraps of old trees left are mixed sessile and pedunculate oaks with the former increasing on the higher eastern edge. On the clayey ground at the foot of the slope up to the first hedge coming in on the north side there are no sessile oaks. Above that they appear and then predominate along the south margin. Outside the fence of the inclosure, except for a few younger trees, the oaks are all sessile. There are five large old sessile oaks on the margin due north of 'Wood', and another group of six old sessile oaks south-east of 'Wood' also outside the fence. At the south-east bulge there is one isolated sessile oak. All this is very strong evidence that when the inclosure was formed it was so located as to take in part of the remaining natural sessile oakwood on the higher ground. Most of the trees remaining inside the east margin of the wood are sessile oaks. The pedunculate species was probably planted in the open spaces through the wood and on the lower slopes.

2. *Bentley, South.* Here the old stand consists of rather fine, nearly pure sessile oak, except in the bulge to the west on the lower ground, where some pedunculate oak occur as in (1) above. This is probably the best mature stand of sessile oak now inclosed and there is quite a lot of good natural regeneration in the opened out portions.

3. *Burley Inclosure.* This is all very old beech and pedunculate oak. The trees are large but now rather decrepit, like those in Mark Ash, Wick Wood, &c. The stand is so very similar, indeed, to those already described under B that it would not be surprising if it were really a pre-1700 inclosure.

4. *Puckpits Inclosure.* The old stand is a mixture of pedunculate oak, sessile oak, and beech. The sessile oak is confined to an area on the higher ground along the north-west side and is represented by tall but very old stems, which are beginning to go at the top. This area occupies a position between Mogshade Hill and Stonard Wood and here, too, it is very probable that when the inclosure was made some of the remaining natural sessile oakwood was taken in on the higher ground. The pedunculate oak and beech are very large and imposing on a ridge of unusually deep sand. The pedunculate oak, however, all have poor crowns, especially where exposed to the west wind, and the wood is much decayed. The beech belt on the sandy ridge is unusually strong and has made a valuable shelter.

5. *Prior's Acre.* This area has been swallowed up in King's Garn Gutter Inclosure (1810) (see item 75). Few trees of the older stand remain, but some of them are sessile oaks. The area could also have taken in a portion of the natural woodland on the higher ground.

6. *Rhinefield, Old.* The younger wood which now occupies this old inclosure, especially on that part now covered by Pound Hill Inclosure (item 71), contains some of the best middle-aged stands of oak in the forest. These are sessile and may have been grown from seed collected locally in this part, but they have been planted and have not derived from natural seeding.

7. *Salisbury Trench.* This inclosure still carries (1949) scattered seed-trees of the original crop of sessile oak and the young regeneration is pure sessile oak, with a few surviving planted pedunculate oaks. This is the best example of managed natural regeneration in the forest and the site is, on the whole, too poor for pedunculate oak. Below Salisbury Trench is Gibbet Wood (XI), and above it there are old sessile oaks between the fence and main road. Some of these on the ditch and bank are very nice trees, suitable for reservation as élite trees. It is clear that Salisbury Trench was originally part of the main massif of sessile oakwood in these parts, linking up with Raven's Nest, Copse of Linwood, and Long Beech. It is important as it indicates the possibility of successful regeneration of sessile oak on relatively poor ground when conditions are suitable.

8. *Woodfidley, Old.* All scattered oak through the conifers, except as described below, are pedunculate. Along the north edge of the triangular area north of the word 'Woodfidley', however, some 10 to 12 small to medium-sized sessile oaks occur with the pedunculate species. Both species are scattered, but the former have better crowns. In the old beech belt—obviously from the 1700 planting—there are no sessile oak and, now, no pedunculate oak either. The beech are good. Around the belt, which is on a well-marked ridge, are Scots pine and oak of the 1860 planting. The oak of this age are pedunculate, except for about six trees towards the south apex of the triangle, one of which is a very good specimen. Another sessile oak was found in the south-west of the compartment to the south of the triangle. In the compartment next but one to the south-east, the pedunculate oaks are poor and there are no sessile oaks.

These sessile oaks may have originated from seed dropped by former sessile mother-trees of the 1700 planting or which were remnants of former sessile oak-

wood linking up with the Hawkhill area. It is most probable, however, that they have arisen avificially from acorns brought in from Hawkhill.

9. *Black Bush.* Cleared completely of any 1756 crop and now merged in the Denny Lodge Inclosure (1860, No. 74). Now mainly Scots pine with a sprinkling of beech and pedunculate oak. Oak seedlings coming up here are pedunculate; no sessile oak seedlings seen.

10. *Etherise Inclosure.* The old 1756 crop is gone. The north half has recently been cleared and converted to conifers. The east end of the southern half contains various conifers in mixture with oak, all of which seem to be pedunculate, presumably planted in 1853. In the western half, however, there is a fair sprinkling of sessile oaks of young and middle ages through the Scots pine—in places more sessile than pedunculate oak. These could have been carried in from King's Hat by birds or might have been seedlings from seed-trees of sessile oak in the 1756 stand.

11. *Pignall Inclosure.* No signs of a 1756 stand. The present stand is mainly middle-aged Scots pine with oak. In the north-west corner are clumps of sessile oak mixed with a few pedunculate oak. These clumps extend over a zone to the south-east, but give way to pedunculate oak beyond which have evidently been planted. On the hill-top, around 100 feet, there is an area of pure pedunculate oak about 60–70 years old, which is by no means robust. Here, too, the sessile oak may have been brought in from King's Hat or have originated from seed-trees of sessile oak in the previous stand or may have been planted with the pedunculate species.

Summary for the period 1700 to 1756.

Of these eleven areas, items 1, 2, 4, and 7, when considered along with the areas already dealt with in A above, furnish very strong supporting evidence for the existence of a large massif of natural sessile oakwood on the high-lying northern half of the forest. They fill in gaps in the belt already presumed to have existed, and as inclosures they show signs of having been so laid down as to include at least some of the existing woodland along with bare ground. Except for Salisbury Trench, it is suggested that pedunculate oak and beech were planted in the open parts and on the lower ground. Item 5 presents little evidence, but what there is supports the above view.

As already suggested, item 3 closely resembles the pre-1700 plantations and here, at least, it would seem that no sessile oakwood remained to be inclosed. Item 9 gives us no information. The remaining four items, 6, 8, 10, and 11, no longer carry any remains of the 1700 or 1756 crops, but all have elements of sessile oak in their present stands. They are most probably the result of planting, almost certainly so in item 6, but the possibility is not excluded of their having originated from sessile oak mother-trees in the former stands or—which is more likely—avificially from seed-trees some distance away, in Hawkhill or King's Hat.

C (2) Inclosures Reputed to have been made in 1775

These are ten in number, indicated on the key-map by the numbers 12 to 21.

12. *Alderidge Hill.* This area was reinclosed in 1809 and should probably be

transferred to the C (3) class. The old stand has now been cleared and there is a considerable area of dense natural regeneration of oak of some age on the ground. Only one young sessile oak was seen in this stand, which may have originated from an acorn brought in by birds or from a seed-tree in the original 1775 planting, which presumably did so badly that the area had to be reinclosed and replanted in 1809, and thus with pedunculate oak.

13. *Copse of Linwood Inclosure.* The old stand has recently largely been cleared, but considerable belts have been left from which it is clear that the stand contained both sessile and pedunculate oaks. Along the top margin the species are mixed, but the pedunculate oak increases along with beech towards Fritham House outside the fence. These trees are quite large with only an occasional sessile oak amongst them, but this area is shown as unwooded on the 1789 map. Inside the fence of the scattered old trees left about one in four is sessile oak, but down in the south-east corner against Gibbet Wood there is a narrow belt of good sessile oak.

Towards the north apex in compt. 1 is a hollow with beech and dense holly. In this are old sessile oaks and some young seedlings. Through the Douglas fir plantation in compt. 2 are groups of young sessile oaks. Farther to the south-east is about half an acre with twenty-one rather old sessile oaks, of rather poor form.

This rather confused distribution can best be explained by assuming that the inclosure was laid down to take in a considerable area of open sessile oakwood, which was planted up with pedunculate oak and beech. The former has been able to hold its own on the better pieces of ground, but even yet on the poorer areas the remaining sessile oaks are more vigorous and robust than the pedunculate species.

14. *Furzy Down.* Now mainly young conifers. Few old oaks left, all of which are pedunculate.

15. *Long Beech Inclosure.* There is much second generation pedunculate oak on the margin of the wood along its south side. Towards the western high ground there are several good tall straight sessile oaks in close mixture with tall beech on two spots along the south-east edge of the wood. These are among the best examples of beech/sessile oak mixture in the forest. Below these down to the stream flowing east below the name 'Long Beech End', the wood is mixed pedunculate oak and beech. North of the stream it opens out, but at the 300-foot contour one comes on a dense fringe of oak and beech, where the vegetation is of *Vaccinium*/cow-wheat type. Here are many young sessile oak seedlings along the fringe and vigorous sessile oak on and within the fringe. An extensive area north of this is occupied by hutments, and right through this area, known as Long Beech Camp, the stand is of pure sessile oak. Many young sessile oak seedlings occur around the huts—presumably owing to the presence of numbers of dogs and cats. Many trees had a heavy acorn crop in 1950, and this is a striking example of the possibilities of natural regeneration of this species in semi-shade. This inclosure also seems to have taken in a considerable extent of the natural oakwood, the bare open places having been planted up with pedunculate oak and beech.

16. *Ocknell Inclosure.* An unexpectedly interesting and important area. West

of the Highland Water there are only one or two large old sessile oaks in the pedunculate oak. The ground is rather poor and the bulk of the oaks on the poorer ground are miserable specimens of pedunculate oak. In the west corner, however, there is a piece of good ground on a slope carrying very heavy old beech and sessile oak. The latter, while not very straight, are tall. Any pedunculate oak here are puny. On the upper margin of the strip and on the upper margins of all the tongues of wood running north, north-east, and east the oak is practically pure sessile oak. The pedunculate oaks within these strips on poor ground are markedly inferior.

Here it is practically certain that the act of inclosing took in fringes of an existing natural sessile oakwood on the higher edges and that the area was then planted up with beech and pedunculate oak, which have survived only on the better ground. The isolated sessile oaks on the lower ground have probably survived from the former woodland. The area of mixed beech and sessile oak is of special interest, indicating along with item 15 that on this ground the sessile oak can hold its own with beech in close canopy, specially if it has had a start in advance of the beech. (See also item 92.)

17. *Pitt's Inclosure.* (Also includes belts round the derelict Ashley Lodge.) All old pedunculate oak; no sessile oaks seen. The trees have mostly thin scraggy, sprawling crowns, except for a few near the sheltered eastern side. This seems to have been an area with no relict sessile oakwood left in 1775, when it was probably quite treeless.

18. *Raven's Nest.* Practically pure sessile oak. Along the side of the main road to Brook there is a row of pedunculate oak, obviously planted. This area links Salisbury Trench with Great Wood.

19. *Rhinefield Sandys.* Now mostly under young conifers. This area was also reinclosed in 1809 and should probably be transferred to class C (3). About 100 yards in from the lodge gate there are four or five old sessile oaks of rather fine type, but the remaining trees here are pedunculate. About 200 yards in there is a younger sessile oak and a third in a mixture of pedunculate oak and castanea—a good, full-crowned tree. No other sessile oaks were seen. It is possible that at least a proportion of the 1775 planting consisted of sessile oaks and that, the bulk of the crop having failed, the new 1809 plantation was mainly, if not entirely, pedunculate oak. On the other hand, these sessile oaks may be descendants of a former stand of sessile oak. On the south-east side are some castanea and Turkey oaks.

20. *Sloden Inclosure (Old).* Mainly large, old and very dilapidated pedunculate oaks with old yews. By the gate on the east side, east of Ragged Boys' Hill, a group of three sessile oaks. A fairly complete examination of the wood revealed no other sessile oak but one or two very full-crowned pedunculate oaks, much yew, and some ash. This area is the site of a former village community and the original natural oakwood was probably completely cleared long ago. The soil is for the most part rather light and sandy and more of a sessile oak type than pedunculate. One can only speculate on the reason for the presence of the three sessile trees mentioned. They could have originated from seed brought in from Holly Hatch.

21. *Wilverley*. On the 1789 map this area is shown as unwooded, and it may therefore be presumed that any oak now remaining from the 1775 planting were introduced to it, and it cannot therefore be used as an indication of the former range of the sessile oak.

Nevertheless, the inclosure is an interesting one. Along the north-east side seen from the road the proportion of sessile to pedunculate oak varies from about 1 in 15 to 1 in 20. There is no marked difference in size, but the heavier foliage of the former is a prominent feature. In the east corner of the wood the proportion of sessile oak is higher. Near there is a good sessile oak outside the fence. Along the south-east side there are fewer sessile oak. In the south-east corner there is quite good pedunculate oak and a large Turkey oak beside the gate west of Wilverley Lodge.

The bulk of the area has recently been converted to conifers, but irregular shelter-belts have been left in the centre and south-west. In the belt along the south side there are a few good sessile oak, increasing in numbers towards the west. There is one group of sessile oaks including one specially large tree on heavy soil adjoining an area of peat. In some of the central belts are one or two groups of vigorous sessile oaks and also in the belt on the south-west side. Half-way between Walden's Orchard and Wilverley Post are some old beech and at least one very fine sessile oak.

Groups of very young sessile oak occur along the sides of some of the rides—which look natural but may have been planted.

It seems certain that a considerable proportion of sessile oak was planted along with pedunculate oak and castanea, which is frequent. Sessile oak could certainly reoccupy most of this area in competition with other broadleaved trees, but one would like to discover the source of the plants or seed used here.

Summary for the 1775 Inclosures.

Of this group of inclosures, items 13, 15, 16, and 18, especially Ocknell's which is rather remote from habitations, again furnish evidence which suggests that remnants of natural sessile oakwood were fenced into them. Again there are beech and pedunculate oak on the lower ground, except in Raven's Nest. The 1789 survey shows the whole of Ocknell's as wooded, presumably because it was planted some 12 to 14 years earlier. If so, much of the plantation on the higher-lying, poorer ground has completely failed. Most of the oaks planted, if not all, were pedunculate.

Item 14 provides little information beyond confirming the use of pedunculate oak.

Items 17 and 20 may be classed together as indicating the absence of relict sessile oakwood in this part of the forest. Here, too, pedunculate oak was used in planting.

Item 21 indicates that a proportion of sessile oak was used with the pedunculate species in planting this area, if we are to accept the map evidence, and also furnishes evidence of the greater suitability of the former for this part of the forest, which seems to have been deforested rather early on.

Items 12 and 19 had to be reinclosed in 1809 and silviculturally should therefore come under the next group, with which they have strong affinities. The occasional sessile oaks in Rhinefield Sandys, however, may be remnants of the 1775 planting.

C (3) Inclosures made in the Period 1808 to 1820

There are twenty-four of these, numbered from 22 to 45 on the key-map. The distribution over the period is as follows: 1808, 4 areas; 1809, 2 areas; 1810, 5 areas; 1811, 6 areas; 1815, 4 areas; and 1820, 3 areas.

22. *Holly Hatch* (1808). The greater part of the old oak left standing are pedunculate oaks of a rather more vigorous type than usual, but there is a considerable proportion of sessile oak in the centre of the inclosure and near the cottage. These latter may be remnants of an area of former natural woodland included within this inclosure, but the proportion of sessile oak is low towards the eastern bulge on the higher ground, where one would have expected a link with Anses Wood (I).

23. *Hurst Hill* (1808). Originally practically pure oak, which has recently been clear-felled in blocks, irregular belts being left through the area. In the south-west corner the species is pedunculate oak, rather tall but with thin crowns and an underwood of thorn in places. One large old sessile oak stands opposite the eastern apex of the re-entrant on the south-west side, with a large castanea and pedunculate oak alongside. North of these are one or two younger sessile oaks. The bulk of the west side of the inclosure has been pedunculate oak which has grown poorly on a very good site and is now being replaced by Douglas fir. In the marginal strip east of Wide Lawn are two vigorous sessile oaks, and there is a group of ten vigorous sessile oaks in the bend south of the 'N' of 'New Forest' on the map. Still farther east and south of Butt's Lawn there is quite a high proportion of rather good sessile oak in the belts, both as groups and as single trees. Growth generally is superior to that in the western half, but the site is better and more sheltered.

24. *New Coppice* (1808). Considerable parts of the inclosure have been converted to conifers. At the western end and beside the 's' of 'Brockenhurst', many young sessile oaks occur in the mixed stand of Scots pine, ash, and pedunculate oak. There are more sessile than pedunculate oak. As there appears to be no possible seed-tree area near, these seem to have been planted. There is a good group of tall sessile oak, about six, alongside the road half-way between the second milestone from Brockenhurst and Lodgecross Lodge, confirming this view. One area along Etherise Gutter on heavy clay has moderately good pedunculate oak with beech. There is another group of about ten young sessile oak right in the south-west corner under Scots pine.

25. *Wootton Coppice* (1808). Mostly converted to conifers but with some belts of old wood left. The belt along the south side is pure pedunculate oak of poor size and quality. On lower ground in the area north of the word 'Copse' are scattered sessile oaks in the belts and one group of fairly good sessile oaks in one belt, on a part of the area shown as old wood on the 1789 map. The trees are of

the same age as the pedunculate oak and the soil is heavy. They are not markedly larger than the latter, but have better crowns.

26. *Broomy Inclosure* (1809). The west end has recently been opened out for regeneration. The trees are all pedunculate oak. Just south of Holly Hatch Cottage, however, there are a few tall healthy-crowned sessile oaks, linking up with Holly Hatch (22).

27. *Stockley* (1809). Mainly converted to young conifers, especially *Abies grandis*, but some hardwood is left on the eastern side. In this are a few sessile oaks, with fuller crowns but not markedly taller or straighter than the pedunculate oaks forming the main crop, which are not very good. In the south-east bend, however, is a clump of nearly pure sessile oak within the Scots pine belt, which are distinctly superior to the rest of the stand—some six or seven in the group with others scattered through the stand. These are scarcely likely to be remains of inclosed sessile oakwood, but were probably planted.

28. *Church Place* (1810). Much of this has been cleared and replanted recently, but still much of the older woodland remains. All the oaks are pedunculate on a heavy clay, but a gravel ridge runs through the area towards the east side carrying very poor pedunculate oak and beech. However, the hedgerow pedunculate oaks around Ashurst Farm are healthy and vigorous.

29. *Godshill* (1810). A complete tour of this wood revealed no sessile oak. The trees are all pedunculate oaks of the usual weak-crowned type.

30. *Lodge Hill* (1810). (Including *Iron's Hill.*) Partly converted to conifers. The remainder is pedunculate oak of varying quality. No sessile oaks were seen. In places the oak is fairly good and vigorous, but on the whole it is a poor type.

31. *New Burley* (1810). Has recently been cleared in patches and planted with conifers, but chain-wide strips have been left radiating along rides. These belts are nearly pure pedunculate oaks which are quite large but with very weak crowns. One sessile oak only was seen in a strip running east from Lucy Hill (XIX). It was taller and more robust than the pedunculate oaks, but suffering a little from exposure because of the opening up of the stand. Probably this tree was planted with the others, but it may have originated from seed from trees on Lucy Hill or even of a former stand on the ground.

32. *Norley* (1810). Almost all converted to conifers. On the lower ground towards the south-east remnants of oak remain, all pedunculate of poor type. If this was the better part of the 1810 stand, the rest must have been extremely poor.

33. *Anderwood* (1811). All the oak left here are pedunculate with the usual light crowns. The site is definitely a sessile oak site. Formerly there was a good deal of castanea.

34. *Holiday's Hill* (1811). Between stream and fence north of the 'H' in 'Holiday's' is a vigorous fairly old sessile oak. This corner just came into the old woodland on the 1789 map. Four good, tall sessile oaks occur in the mixed wood of pedunculate oak, castanea, and beech.

35. *Holmsley* (1811). Mostly opened out and converted to conifers or mixed plantations, with strips left. On the south side the remnants of old wood are all

of pedunculate oak which is rather poor where not well sheltered, although the soil is above the average. There are a few large trees. In the north corner around Holmsley Lodge there are no sessile oak in the strips. The pedunculate oaks are fairly large but the crowns poor, especially when exposed. There is a proportion of castanea.

36. *Northerwood* (1811). A survey of this newly opened-out stand of oak, beech, Scots pine, &c., revealed sixteen sessile oaks of various sizes, vigorous but not very straight, near the south corner. No pedunculate oak were seen except along the side of the avenue and north of the latter. One large sessile oak occurs. There could be two generations here, large trees from the 1811 inclosure and younger trees which may have arisen naturally as on the adjoining Lyndhurst Hill (XX).

37. *Roe Wood* (1811). Nearly all pedunculate oak, recently opened out for conversion, but there is a row of four or five tall healthy sessile oaks inside the fence due south of Amies Cottage and one tree about 150 yards south-east of the cottage. As there are very old sessile oaks just outside the fence here, these few trees may indicate that part of the natural wood was inclosed.

38. *Set Thorns* (1811). Now cut up into belts as in the case of Hurst Hill. A considerable area of this wood was examined and no sessile oaks found, not even on Oaken Brow. The pedunculate oaks are not very good, but there are occasional large trees.

39. *Amberwood* (1815). No sessile oak seen.

40. *Holm Hill* (1815). Mostly now converted to conifers, but some strips of the old wood have been left through the centre. The oak are all pedunculate and fairly good.

41. *Kings Coppice* (1815). Almost all converted to conifers. A few scattered oak of the 1815 stand left and a considerable area with hazel underwood on the east side. All oaks are pedunculate of poor type.

42. *Ramnor Inclosure* (*Part*) (1815). On the west margin is a strip of mature oak about a chain wide which has been retained as a shelter-belt. This is pure pedunculate oak down to a point 390 yards south of the gate, when it changes to sessile oak, which is markedly more vigorous—one of the most striking contrasts seen in the forest. East of this strip is young oak regeneration which was not closely examined, but seemed to be mainly pedunculate.

43. *Beechbeds* (1820). A very varied stand with some nearly pure castanea which is quite good, and also some good groups of beech. In places there is mixed beech and pedunculate oak and some pure pedunculate oak which is very poor in places. No sessile oak were seen, but there is a fine isolated specimen of Scots pine.

44. *Little Holm Hill* (1820). Pure pedunculate oak with some beech on a heavy soil. The type of oak is good and resembles that in Bratley Inclosure (48) and Ivy Wood (52). No sessile oak seen.

45. *Over Corner* (1820). Formerly mixed with castanea, now nearly pure pedunculate oak on good soil; one of the best groups of that species in the forest occurs at the sheltered north-east end. Exposure has affected those on the higher ground to the south-west.

Summary for the Period from 1808 to 1820.

Before passing any comments on the above inclosures it should be pointed out that a great deal of propaganda had been issued since the 1775 plantings under the name of T. Nichols (1791 and 1793) and others, in favour of the pedunculate oak and decrying the sessile or durmast oak (*Observations on the Propagation and Management of Oak Trees in General*, &c. (1791) (7) and *Methods proposed for Decreasing the Consumption of Timber in the Navy* (1793) (8). He deprecated the planting of durmast oak in some of the 1700 inclosures. If we are to assume that the use of sessile oak was entirely suspended, then the presence of the few trees of that species in items 22, 23, 24, 25, 26, 27, 31, 34, 36, 37, and 42 could be assumed with greater certainty to indicate that their origin was due to the presence of older seed-trees in the vicinity. Apart from Roe Wood Inclosure, which almost certainly took in a fringe of former natural sessile oakwood, however, it is not unlikely that a small proportion of sessile oak was still being used, especially up to 1809. Except in Ramnor Inclosure the complete absence of sessile oak in the 1815 and 1820 areas is almost certainly due to policy.

Except on the better soils, and sometimes even there, the pedunculate oak is not at all happy, which explains why so much of these areas has since been converted to conifers, which is perhaps not the best solution.

C (4) Inclosures made in 1829

These are ten in number, shown as 46 to 55 on the key-map.

46. *Appleslade*. Twice examined and no sessile oaks found, although specimens occur in Red Shoot Wood (XXV) right up to the fence on the south-east. The pedunculate oak have very poor, blasted crowns. The stand is now very open with heavy bracken growth and it makes a most marked contrast with Red Shoot Wood.

47. *Backley*. Beech and pedunculate oak; no sessile oaks seen.

48. *Bratley*. All pedunculate oak forming a fairly complete crop, and although the crowns are light, this is one of the best stands of that species in the forest.

49. *Costicles*. Most of this has been felled and replanted, but the parts round the margin of the 1829 stand which still remain consist of quite good pedunculate oak and beech, which are healthy but not large. Some parts have good soil and the vegetation is fairly rich. No sessile oaks were seen.

50. *Fletcher's Thorns*. Pedunculate oak; no sessile oaks seen.

51. *Fools Gate*. The stand consists of pedunculate oak and beech.

52. *Ivy Wood*. One of the best stands of pedunculate oak on rich clay. Also some ash, but no sessile oaks.

53. *Ramnor* (*Part*). Pedunculate oak; no sessile oaks seen.

54. *Stubby Copse* (1829). A low clay hill with very heavy soil. Practically pure pedunculate oak of the usual 1829 type, but very short and wind-blown in places, especially towards the higher ground. In process of being cleared and converted to conifers, but belts remain in places. About six sessile oaks of larger size than the pedunculate oak are scattered around the ride junction north of the 'p' in 'copse'.

One young sessile oak under a Scots pine at the ride junction north of the 'S' in 'Stubby'.

55. *Wooson's Hill.* Most of this area has been converted to conifers, but some mixed pedunculate oak and beech are left. In the middle of the strip east of Barrow Moor there are one or two sessile oaks.

Summary for the year 1829.

Apart from about ten sessile oaks in items 54 and 55, which may have originated casually, the evidence for this period shows that the policy at this time was to plant nothing but pedunculate oak. On the whole the areas were planted on good or moderately good sites, and results were better, Appleslade being an exception, but it is more exposed.

C (5) Inclosures Made in the Period 1843 to 1853

There are fourteen items in this period, numbered 56 to 69 on the key-map.

56. *Buckford* (1843). (Including *Water Copse.*) Rather good pedunculate oak, but the canopy is light and there is a heavy growth of *Rubus.* No sessile oaks seen.

57. *Clumber* (1843). The east end of the larger part contains two sessile oaks amongst middle-aged pedunculate oak. In the Little Inclosure there is a group of five or six middle-aged sessile oaks in the south corner, the rest being pedunculate.

58. *Ferny Knap* (1843). There are two blocks of oak in this small inclosure, which have been surrounded by a belt of conifers, but the belt has been opened out so as to expose the western edges of both blocks of oak. The western block is pedunculate oak and the eastern one is sessile oak, consisting of about 100 trees, recently opened out. The latter appear to be on the poorer site, if there is any difference. Both species are suffering from severe exposure, but the crowns of the sessile oak are definitely less damaged. Both species are producing numerous epicormic shoots. The sessile oak stand is denser and the canopy is more complete, but the crowns are generally small and light. They are about 70 feet high and taller than the pedunculate oak but not any stouter. The soil covering is very light bracken, *Polytrichum* and scattered *Holcus.* Under the pedunculate oak it is the usual heavy bracken. Future developments of these two stands should be of interest.

59. *King's Hat* and *Hartwell* (1843). In both these all oaks are pedunculate. In the former they are of quite good type on fairly good ground and there are also some castanea and Scots pine.

60. *Stubby Copse* (1843). A great part of this area is, after thinning, practically pure sessile oak of good type on silty clay. Some parts have been pure pedunculate oak and others a mixture of the two oaks, but these have largely been cut out and converted to conifers. In the triangle east of Stubby Copse (1829) there is an area of mixed beech, sessile oak, and pedunculate oak, recently thinned. Several sessile oaks have been left, but they are not so tall as the beech. Farther north still, on a north-east aspect, the stand is now pure beech of fairly good type on a well-drained slope. There is a specially good group of four sessile oaks beside poorer

pedunculate oak at the ride junction south of the south-east corner of Stubby Copse (1829).

61. *Hasley* (1846). In this wood some groups of oak and castanea are left with fringes of larch and Scots pine and some conifers through the stand. Only one sessile oak was seen just north of the 'I' in 'Inclosure', notable for its fuller crown. One good Turkey oak on the south slope just south-east of 'Hill'. On the whole the pedunculate oaks are poor although the soil conditions are above the average. The castanea are good with some very good stems.

62. *Great Linford* (1846). Mainly castanea and pedunculate oak are left, the former much blasted and the latter with very thin crowns, in marked contrast with the nearby sessile oaks outside the fence. Along the northern margin of the inclosure there is a belt of quite good sessile oak with a good canopy. This could have seeded in from Red Shoot Wood (XXV), but its regularity suggests that it was planted in conformity with the other inclosures of this period.

63. *Linford* (1846). No sessile oaks seen.

64. *Pignall Hill* (1846). A very heavy clay soil. Planted with both species of oak, sometimes nearly pure but also in mixture. The purer areas of sessile oak have developed into very nice tall stands, forming some five blocks scattered irregularly over the area, the best block, which is suitable for a sample plot, being between the south corner and the Tile Yard. Some group regeneration of both oaks and Scots pine has recently arisen. As usual the areas with pure or nearly pure pedunculate oak are poorer.

65. *Broadley* (1852). The soil here is a very heavy clay with occasional gravel ridges. Areas have been planted with nearly pure sessile oak and others with pure pedunculate oak and some with a mixture of both, while Scots pine has been used on the higher ground. This inclosure has been opened out for conversion to conifers in recent years, but some belts of oak have been left. There are some promising pure sessile oak belts alongside the road from Wilverley Lodge to Wootton Hill. The trees are tall but slim and the canopy fairly good, in spite of their sudden isolation by removal of adjoining trees. Areas of mixed sessile and pedunculate oak are usually poor and areas of pure pedunculate oak on the higher and poorer ground are very poor. Higher up no pure sessile oak seems to have been planted. (See also item 62.)

66. *Frame Heath* (1852). Largely converted to conifers but considerable strips of oak in the hollows, some of which are fertile areas. Mainly pedunculate oak with one or two good stands on the better ground, but there are also areas of nearly pure sessile oak in the centre of the inclosure. There is a nice group of five on the left of the newly gravelled ride below 'Heath'. Farther on an area which was mixed conifers and oaks has been opened out, and on it there are some very good sessile oaks, but others not so good, and there is much young regeneration of sessile oak, birch, and pine. There are some older groups of regeneration with vigorous young sessile oaks. The older stand contains Turkey oak in one part and it is seeding freely. At the east end of the inclosure are a few young seedlings of sessile oak in the mixed pedunculate oak/pine stand. These have seeded in from the old trees on the Hawkhill area.

67. *Islands Thorn* (1852). This large inclosure occupies ground which is on the whole good. The greater part of it is composed of pedunculate oak with patches of beech, ash, Scots pine, and larch. On the east side on a gravel ridge near the middle of the east edge there are scattered groups of sessile oak. These are always more leafy and vigorous than the pedunculate oak. In all, scattered over a wide area twenty-one sessile oaks were found here, and on the ridge the pedunculate oaks were poor. On the steep flank of the ridge are some good beech.

In the north-west of the inclosure, however, there is a large area of several acres in extent of very good sessile oak, which is nearly pure. The canopy is good, even after a recent thinning. The vegetation is short with some low bracken, &c. This area runs from the word 'Islands' north to the boundary where there is a mixture with Scots pine. It lies east of the ride running north from the 'n' in 'Islands'. West of this ride is a strip with mixed pedunculate and sessile oaks and Scots pine. This is thin and open with heavy vegetation. Still more to the west there is pure pedunculate oak which is much inferior. Beyond that again is a recently clear-felled area, which was pedunculate oak with larch and pine.

There are scattered specimens of both sessile oak and Turkey oak through the pedunculate oak in the lower part of the inclosure. There are several acres of specially good pedunculate oak of a vigorous type, underplanted with beech, on good fertile clayey ground between Cooper's Hill gate and the corner south of the Gunpowder factory. West of the gate are some sessile oaks beside the drive.

68. *Oakley* (1853). Here again there are areas of pure pedunculate oak, areas of pure sessile oak, and areas of mixed oaks. The soil generally is very heavy, and in places there is a proportion of larch and pine which have not done very well. Along the main road to Ringwood the effect of exposure on the pedunculate oak in comparison with the sessile oak is very marked. There is an area of some size of nearly pure sessile oak of good quality about half-way along towards the south-east corner. Just outside the south-west corner of Beechbeds (43) a stand of castanea and oak has been left standing, the adjoining area having been felled for conversion. The eastern extension of this consists of five tall sessile oaks and there are a few seedlings. There is a considerable scattering of sessile oak through the rest of the inclosure, but not many pure blocks, and it always looks better than the pedunculate species. No attempt seems to have been made to relate the species to site changes.

69. *Parkhill* (1853). Areas of old beech and pedunculate oak on higher ground south-west of Burnt Heath. In this large inclosure the planting policy is the same as in Oakley and Islands Thorn, but here some Norway spruce and Douglas fir have also been used. There are some acres of nice sessile oak underplanted with beech on heavy clay, with an eastwards extension beyond a ride. To the north and north-east there is pure pedunculate oak which varies from quite good to very short. Farther east in a ride angle is another patch of sessile oak. Quite a lot of oak seedlings are now coming up in these stands and the 1950 acorn crop was heavy. Towards the west corner of the inclosure are many sessile oaks under and amongst the Scots pine, which seem to have seeded in from King's Hat (XVI), but may have been planted.

Considerable areas of the inclosure have been felled and seed-trees of Scots pine left, although the ground is really not pine ground. The better blocks of oak have been left, much of it being pedunculate and not very good. Between the 'P' of 'Parkhill' and 'c' of 'Inclosure' there is an acre or two of nearly pure sessile oak which is in distinct lines and obviously planted. Good contrasts between the two species are to be found in this inclosure. There seem to be no pedunculate oak north of the ride running east to west below the 'F' of 'Forest'.

Summary for the Period from 1843 to 1853.

Excepting items 59, 61, and 63, all the items described are very similar. A feature of these areas is the use of conifers in mixture with the oaks and the general use of both species of oak. Evidently the prejudice in favour of pedunculate oak had faded out, but there seems to have been no clear idea as to the relative site requirements of the two species. Indeed, it usually seems that the sessile oak was planted on the better, less exposed ground and often on very heavy soils. The general superiority of the sessile oak is manifest on all but the very best sites and there is no doubt that it can drive out the pedunculate species without assistance, but in fact it is now being assisted—probably unintentionally—because thinning operations tend to favour the best trees and in most cases that means the sessile oak in mixtures. The poor showing of many of the pure pedunculate oak stands has led to their clearance and conversion to conifers. There should be some very good stands of sessile oak in Islands Thorn, Stubby Copse, Pignallhill, and Parkhill if they are kept to maturity.

C (6) Inclosures Made in the Period from 1859 to 1862

There are nine of these, numbered 70 to 78 on the map.

70. *Dane's Slough* (1859). This inclosure includes an area of very old decadent beech, through which are groups of younger pedunculate oak, which are good. Belts of oak have been left through the inclosure, which is generally on rather poor soil, and the pedunculate oaks are sometimes very poor. Beside the Ringwood road, however, there are some very good pedunculate oaks with five sessile oaks, two small and three large, amongst them. There is another isolated sessile oak south of Dog Kennel Bridge in the apex of the triangle. Where isolated large Scots pine occur on open margins against the oak, there are numerous oak seedlings. This feature is noticeable elsewhere, and Scots pine left as seed-trees provide centres for the dispersal of oak where the ground is suitable and oak seed-trees not too far away.

71. *Pound Hill* (1859). This inclosure contains some of the finest sessile oak stands in the forest, although they are not of great extent. There is one stand in particular, about 3 acres in extent, east of the ornamental drive, which may have sheltered it. Beside it are pure stands of very poor pedunculate oak, beyond which again are better stands of sessile oak, forming the best contrasts in the forest. Towards Fletcher's Thorns there are areas of nearly pure sessile oak underplanted with beech. The canopy is good and high east of the drive and east of Scrag Hill

nursery. The proportion of pedunculate oak increases towards the east and the oak finally gives place to conifers. Some of the trees are rather crooked, but the higher the proportion of sessile oak in the stand, the better the stand and the cleaner the ground. Part of this area coincides with Rhinefield Old Inclosure (6).

A sample plot taken here in 1950 gave the following figures per acre: 129 oak and 5 small beech; basal area, 108 hoppus sq. ft.; mean quarter girth, 11 in.; mean height, 82¾ ft.; volume 3,565 hoppus ft. over-bark; C.A.I., 72·8 h. ft. or 2·04 per cent. The adjoining pedunculate oak had a mean quarter girth of 8¾ inches and a mean height of 60 feet only.

72. *Vinney Ridge* (1859). Only a part of the inclosure has been planted with broadleaved trees. On Brock Hill near the top on the north-east slope are two sessile oaks with the pedunculate oak, and beneath them a few seedlings. There is another on the edge of the ditch above the flat which carries quite good pedunculate oak. Another full-crowned sessile oak stands in the oak strip farther west. Four other good sessile oaks occur just west of the ornamental drive, one of which bore many acorns in 1950. Here, too, are some Turkey oak seedlings, presumably from the trees along the main road. East of the ornamental drive is a block of quite good sessile oak amongst less good pedunculate oak. A very good élite sessile oak stands beside the notice-board saying 'Douglas fir planted in 1947', and there are still brocks on Brock Hill!

73. *Brockishill* (1860). Just east of Little Stubby Hat are a few sessile oak in the pedunculate oak, the latter being very poor. North of this are scattered sessile oaks through the Scots pine. North of this again one finds a considerable quantity of sessile oaks around the cross-rides just west of Nicholas corner. A belt of good sessile oak on the west of the ditch due south of Nicholas corner forms a fair-sized plot. There are numbers of sessile oak seedlings scattered through the Scots pine.

74. *Denny Lodge* (1860). Most of the scattered oak seedlings through this area of conifers are pedunculate, but there is a considerable sprinkling of sessile oak through the older mixed stand in the triangle south of Denny Lodge, probably brought there by birds.

75. *King's Garn Gutter* (1860). Mostly an area of conifers, but there are two patches near the south-east corner of about an acre each with middle-aged sessile oak of not very good form, mixed with beech and larch in one case and with a fringe of pedunculate oak in the other. These seem to have been planted. On the other hand, there is a high proportion of sessile oak in the narrow Scots pine screen left along the south side of the inclosure. These seem to have been seeded in from the south. This seeding is still going on and many young sessile oaks are coming up under Scots pine seed-trees. In the southern angle pointing to Long Beech Hill is a middle-aged strip of sessile oak within the old Prior's Acre Inclosure (5). On the north-east side against Coalmere Lawn one sessile oak occurs. Along the south-west edge towards Dane's Hole there are more sessile oaks in the Scots pine fringe. Outside the fence are old beech and pedunculate oaks, but isolated trees and groups of sessile oak also occur. The beech are deteriorating and the soil is becoming degraded. Beside Dane's Hole are two good oaks, one pedunculate and the other sessile. Within the fence are vigorous youngish sessile oaks

through the Scots pine seed-trees. Within the old Prior's Acre area are three areas of about half an acre each of young sessile oak and beech about 40 feet high. The oak are rather poor and open. There is a much larger and better area of this type on bilberry-cow-wheat ground, still within the old inclosure but more to the north. One sessile oak below the 'a' of 'Garn' had a heavy crop of acorns in 1950 and many sessile seedlings were around. The soil is a clay. Three large old sessile oaks occur just north of the word 'King's' and some smaller pedunculate oaks.

Up towards the north-west corner outside Prior's Acre is an interesting area of old sessile oak and beech in a hollow. Amongst the old trees is a nice fully-stocked group of middle-aged sessile oak.

Near the north edge by the 300-foot contour is a good old pedunculate oak.

This inclosure displays some unusual features. It is not possible to say what the stand on Prior's Acre was, but the sessile oak still left indicate that at least a proportion of the stand was sessile, as one would expect from its position between Long Beech and Copse of Linwood. The newer inclosure of 1860 seems to have taken in at least one remnant of the former sessile woodland, protected by the old inclosure fence and that remnant has succeeded in expanding. The fresh invasion of sessile oak from Long Beech is interesting. The old beech and pedunculate oak around Dane's Hole are reminiscent of those beside Fritham House.

76. *Shave Green* (1860). No sessile oaks were found in the oak areas within this inclosure.

77. *Milkham* (1861). Most of this area is young conifer forest, but there is a middle-aged pedunculate oak stand left south of Spring Bushes, similar to the Knightwood (83) areas.

78. *Shufters* (1862). Similar to 77. One or two small patches of oak remain on both sides of Highland Water and west and south-west of Bratley Arch and are all pedunculate.

Summary for the Period from 1859 to 1862.

The areas planted during this period contained considerable expanses of poor heathy ground on which pine was used. The oaks were confined to the wetter grassy hollows as in items 70, 72, 73, 76, 77, and 78. The species of oak used was almost exclusively pedunculate oak, but scattered sessile oak occurs in the first three areas. The Pound Hill Inclosure is an exception and quite a high proportion of sessile oak was used here with very good results. Few if any oak at all were used in Denny Lodge. The King's Garn Gutter area is exceptional and seems to have taken in an area of uninclosed old woodland of varying composition on the high ground, but the bulk of the inclosure was formed from the old Prior's Acre area, which may account for the proportion of middle-aged sessile oak occurring in odd patches.

C (7) Inclosures Made in the Period from 1864 to 1870

There are eight of these, numbered from 79 to 86 on the key-map.

79. *Busketts Lawn* (1864). Careful examination of the strip of oak still left standing on the low-lying grass hollows within the pine main blocks revealed a

total of eight sessile oaks, on the whole not much larger in size than the pedunculate oak but with fuller crowns. The amount of epicormic shoots consequent upon the recent thinning was similar on both species. As there seem to be no old sessile oaks near, it appears that a mixture of the two species was planted. A few of the pedunculate oaks are unusually robust and may be of a different strain. A few young sessile oak seedlings occur in the belt. The area to the east of the belt is a very good example of natural seeding of pedunculate oak and beech into Scots pine, only one sessile seedling being found there, a reflection of the proportion of available mother-trees.

80. *Sloden's* (1864). Pedunculate oak—no sessile oaks seen.

81. *Perry Wood* (1866). (*Iron's Hill.*) The stand is mainly Scots pine, but there are thinly scattered young pedunculate and sessile oaks throughout, the former being more abundant. The wood has just been thinned, all species being reduced. The proportion of pine is high and the oak generally are very poor. There are some scattered old beech and pedunculate oaks on Iron's Hill, but no old sessile oaks were seen. North of the railway this inclosure is pure conifers.

82. *Deer Leap* (1867). The stand is coniferous.

83. *Knightwood* (1867). The bulk of this area is under conifers, but the low-lying grassy strips along the streams were planted with oak. These are mainly pedunculate with an occasional exceptionally vigorous specimen as in Busketts Lawn. There are patches of sessile oak, however, one running in from Warwick Slade towards Ferny Knap, having the usual dense canopy. There are also one or two sessile oaks in a group just west of the Eagle oak. There is another group in the strip running up towards Wooson's Hill, near point 104. In an oak patch north-east of Eagle oak there is a Turkey oak and more of that species beside the Knightwood oak, which is pedunculate. There is also one young sessile oak on the Great Birchen Hat. In a hollow beside the older Corsican pine stand is quite a good group of pure pedunculate oak.

84. *Highland Water* (1869). Almost entirely conifers. The eastern corner near Robin's Bush, however, consists of poor pedunculate oak mixed with Turkey oak. Rather a better strip of pedunculate oak also with one Turkey oak occurs west of Wick Wood. Reference has already been made to a solitary sessile oak on the north-east side (26).

85. *Denny* (1870). Largely conifers; no sessile oaks seen.

86. *Hawk Hill Inclosure* (1870). One or two small areas of very old oak on heavy ground. These are all pedunculate with poor crowns. The younger oak are all poor pedunculate oaks, no sessile oaks being seen.

Summary for the Period from 1864 to 1870.

During this period the main species planted was Scots pine on heathy ground, oak being confined to the grass hollows. The latter was rather a mixed lot, including Turkey oak and various strains of pedunculate oak—some of which may, I suppose, have been hybrids. On the whole the ground planted was below average fertility for the forest and not very suitable for oak. Hence a relatively high proportion of the ultimate survivors will be of the sessile species, which occurs very sparingly.

C (8) Inclosures whose Date of Inclosure has not been determined

There are eight of these, numbered from 87 to 94 on the key-map.

87. *Brick-kiln.* Except at the north end, which has a gravelly cap, the soil of this inclosure is very heavy. At the north end are vigorous maturing sessile oaks scattered through the pedunculate oak, beech, and castanea, south and south-west of Pinkley Farm. There are occasional vigorous sessile oaks in the belts left in the southern half, but also some good pedunculate oaks. (The young oak sowings of 1932 contain a good proportion of sessile oak and look promising.) Judging by the composition this might be an 1846 plantation.

88. *Brownhill.* A gravelly ridge mainly with young conifers. The few oaks seen were all pedunculate.

89. *High Coxlease.* Mixed conifers and hardwoods. Oaks are pedunculate, of middle age and weak.

90. *Little Wootton.* This inclosure seems to have been thrown open. It is mostly cleared, but any oaks left are all pedunculate, some west of Wootton Farm being fairly good.

91. *New Park.* A good stand of pedunculate oak, castanea, and beech—tall and well stocked. On Goldsmith's Hill the oak is nearly pure but much poorer, yet it improves again southwards on the lower ground towards Queen's Bower. Similarity to Beechbeds Inclosure would suggest that this was an 1820 plantation. There is a small group of five or six good sessile oaks in the triangular area just north of Bolderwood bridge.

92. *Park Ground Inclosure* (1810). Within the southern bend of this area, recently thinned, are some mature sessile oaks, at least six of which are good trees. To the east of these are some pedunculate oaks, all in mixture with Scots pine. East of the main Brockenhurst road on Clay Hill are several acres of vigorous sessile oak in mixture with beech and castanea—evidently thinned several times and now 140 years old. The trees are tall but the crowns of some are much forked. Outside the inclosure east of the main road on Clay Hill there is one large sessile oak. Within the inclosure passing southwards at about 300 yards the sessile oak gives way to pedunculate oak, which is less vigorous except in the moister hollow. A sample plot was taken in this sessile oak stand as it was the best-stocked still vigorous old sessile oak stand met with (heavily thinned, however, in 1950). There were 44 oaks per acre with a basal area of 78 hoppus sq. ft., a mean q. girth of $16\frac{1}{8}$ in., a mean height of 80 ft., and a volume of 2,330 h. ft. per acre over-bark. There were in addition 35 beech and 1 castanea with smaller girths but the same height and a volume of 1,120 h. ft. per acre. The increment on the oak was determined as 34·3 h. ft. per acre or 1·67 per cent. These trees have obviously furnished seed for some of the nearby groups of sessile oak in the north end of Whitley Wood (XXXV). It would be interesting to find out why these came to be planted in a stand of the period from 1808 to 1820.

93. *Pondhead.* This is mainly pedunculate oak and beech, not unlike the last, but only one or two old sessile oaks were observed.

94. *Roe.* Mainly conifers. The strip of hardwood within the fence is all pedunculate oak. Probably handled along with Milkham Inclosure (1861) (77).

Summary for Items 87 to 94.

Brick-kiln and Park Ground Inclosures may be commented on. It is not improbable that remnants of old sessile oakwood may have occupied the gravel ridge which runs through the top ends of these inclosures or that scattered sessile oaks remained which could have furnished seed to spread sessile oak through the top ends of the inclosures, where we find the bulk of the present sessile oak crop. This view is supported by the presence of old sessile oak outside the inclosures. Be that as it may, both inclosures have provided seed which has enabled groups of sessile oak to establish themselves in the adjoining old plantations of beech and pedunculate oak.

D. Uninclosed Woods, Relatively Young with no Sessile Oak

There are innumerable examples over most of the forest, wherever conditions of protection and soil are suitable, where natural regeneration of pedunculate oak, often mixed with beech, has been going on over a long period of years. These stands therefore vary a great deal in age. It would confuse an already congested map to number these and show the numbers on the map. Instead the following list gives the names of all such woods inspected, so that they can be identified on the 6-inch maps if desired. The list refers to thirty-six localities.

Amies Wood, Ashley Cross Hill, Bell's Hat, Budger's Wood, Burnt Heath (east of), Castle Hill, Clay Hill (2), Cockley Bushes, Coalroad Hill, Cufnell's, Durmast Hill, Gorley Bushes, Great Dark Hat, Great Hat, Great Huntley Bushes, Hazel Hill, High Corner Wood, High Croft Wood, Howen Bushes, James's Wood, Linwood, Little Wood, Marrowbones Hill, Ocknell Arch, Pig Bush, Pigsty Hat, Pondhead (east of), Redrise Hill, Rhinefield nursery, Round Hill, Rufus's Stone, Tintany Wood (parts of), Twelfth milestone from Romsey to Ringwood, Wide Lawn, Woolsmoor Meads, Yewtree Holms.

The frequent occurrence of the names 'bushes', 'hats', and 'holms' in the list gives a clue as to why some of these stands were able to originate and survive.

CONCLUSIONS.

The following are briefly the salient points which this survey has brought out.

1. The numerous examples of relict sessile oakwood outside recorded inclosures, as well as evidence of similar remnants having been fenced within certain, mainly earlier, inclosures, indicate with certainty that there was an almost unbroken massif of sessile oakwood in the northern high-lying part of the New Forest up to relatively recent historical times.

2. There is less evidence of this having been so in the southern half. Nevertheless, important remnants still occur there, which suggest that sessile oakwood of a similar type also occurred there. Being more accessible, it was more quickly devastated.

3. Pedunculate oak mixed with beech is not a normal natural association, and the general appearance, state of health, and regularity of the old uninclosed woodlands of these species confirm Lascelles's views that these areas represent the

earlier plantations. If this is so, the presence of *both* species in the New Forest can be attributed to artificial introduction.

4. Both pedunculate oak and beech have, however, seeded themselves frequently for centuries over areas suitably protected from animals, but only on the best soils have they produced healthy stands.

5. Signs of soil degradation are evident on the infertile sites under both these species.

6. While the sessile oak must have regenerated itself naturally in some parts, it also seems to have been planted, but in decreasing proportions, up to the year 1809.

7. Probably as a result of propaganda in favour of the pedunculate species, the planting of sessile oak ceased between the years 1810 and 1829.

8. In the period from 1843 to 1853 sessile oak was again used in mixture with pedunculate oak, but selection of site was not very satisfactory. In fact, the sessile species seems to have been regarded as the less hardy tree, but in several inclosures pure blocks and mixed blocks were planted, presumably experimentally.

9. In subsequent periods more and more conifers were used and less fertile areas were inclosed. Both species of oak were still in use to a limited extent.

10. Wherever vigorous seed-trees of sessile oak are available, the species is able to extend its range, even into stands of pedunculate oak and beech where the pedunculate oak does not seem capable of establishing itself.

11. The greater vigour and vitality of the sessile oak and its greater resistance to exposure, which are evident all over the forest, ensure that it will increase in importance as time goes one, because it is automatically favoured in thinning operations. A number of promising middle-aged nearly pure stands should develop into fine stands in the future.

12. Sessile oak should be encouraged in future until it has recovered much of the ground it has been driven from, but soil deterioration has gone so far over much of the forest that it will be impossible fully to re-establish the sessile oak.

13. The few remaining relict areas of sessile oakwood outside inclosures should be protected, especially Red Shoot Wood, King's Hat, Bramshaw Wood, Stonard, Gibbet Wood, and Hawkhill. They should be purified by removal of pedunculate oak and beech. Certain areas inside inclosures, such as S. Bentley and Ochnell, should also be specially treated.

14. Pedunculate oak and beech should be confined to the very best sites, which are not of great extent. Under the conditions of climate and soil which hold over a great part of the forest, it is very doubtful if beech is an aid in preserving soil fertility. It lacks that value on certain of the drier sites, and its presence on these in abundance is a hindrance to regeneration of the oaks.

15. The course of events as brought out by this survey is an indication of a process of replacement of sessile oakwood by artificial woodlands, consisting mainly of pedunculate oak and beech, which has taken place over the greater part of the country. This process is undesirable because silviculturally the sessile oak is much the better tree on all oak sites.

16. It is vitally important that the silvicultural differences between the two

DISTRIBUTION OF SESSILE OAK IN THE NEW FOREST IN 1950

Unenclosed Woods with Sessile Oak, numbered thus XXV
" " " *no Sessile Oak* lettered thus S
Enclosed Woods numbered thus 25
Pure or nearly pure Sessile Oak
A High proportion of Sessile Oak (natural)
" " " " " " *(planted)*
A small proportion of Sessile Oak
Isolated Trees (natural or relict)
(artificially introduced)

N

3¼ miles

0 1 2 3 4 5 6 Miles

species of oak should be better appreciated in the future than they have been in the past, and that, in an area like the New Forest, a very substantial matrix of what was, after all, the main natural species of tree, with its associated underwood, should be re-established and that all other species should take the subordinate place which their several merits may justify.

17. Possibilities for the study of the probable stand structure of natural oak-woods exist in King's Hat, Lyndhurst Hill, Red Shoot Wood, and Rushpole Wood. Such a study could furnish important information on the optimum size of group for group-planting with the object of systematic management on the group selection system.

18. In any study involving 'oak' it is absolutely essential to differentiate between the two species, because it is clear that specific differences are a major factor in the ecology, silviculture, and production of the two species.

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BUTT ROT BY *FOMES ANNOSUS* FR. IN EAST ANGLIAN CONIFER PLANTATIONS AND ITS RELATION TO TREE KILLING

By J. RISHBETH

(*Botany School, University of Cambridge*)[1]

SUMMARY.

A short account is given of the incidence in East Anglia of butt rot of Douglas fir, larch, and spruce caused by *F. annosus*. The earliest stages do not differ from those found in the killing of pines; small living roots are infected by contact with stump roots containing the parasite. In young conifers killing is associated with a low resistance to invasion of all tissues. By the time conifers are about 25 years old, however, resistance has increased markedly. In pines all tissues tend to become resistant, checking growth of the parasite, whereas in the other species only the outer tissues become resistant. Thus in large roots of Douglas fir, larch, and spruce, *F. annosus* grows far more rapidly in the inner wood than in the outer wood and bark, from unaffected regions of which small branch roots may be formed. The parasite enters the butt from one or more rotted roots and may then ascend several metres in the heartwood. Secondary fungi are often present in such advanced stages of rot and interesting successions can be traced. The relation of butt rot to thinning is discussed and ways in which various factors may influence the disease are suggested.

INTRODUCTION.

IN earlier papers [Rishbeth (6) to (9)], killing of pines (*Pinus sylvestris* L. and *P. nigra* var. *calabrica* Schneid.) by *Fomes annosus* Fr. in East Anglian plantations was considered in some detail. Although this parasite probably kills very young conifers widely throughout Britain, surveys such as that of Peace (4) indicate that it more typically causes butt rot. This is almost certainly true throughout the geographical range of *F. annosus*, for most previous workers refer to the fungus as causing butt rot rather than death of conifers. As far as is known, the relation between these different manifestations of parasitic activity has not been discussed before and, in addition, there is considerable difference of opinion about the way in which butt rot is initiated. Some observations on butt rot made in East Anglia, where killing of conifers is more generally prevalent, may therefore be of interest.

SPECIES AFFECTED.

First, it is worth recording that, in East Anglia, conifers other than pines are killed outright by *F. annosus* as young trees. Douglas fir (*Pseudotsuga taxifolia* (Poir.) Britt.) and larch (*Larix decidua* Mill.) are killed near infected stumps soon after planting on former woodland, as are the less common spruce (*Picea abies* (L.) Karst.) and Lawson's cypress (*Chamaecyparis lawsoniana* Parlatore). Douglas fir, mixed with pine, has been attacked as severely as the latter tree on

[1] Now Plant Pathologist, West Indian Banana Research Scheme, Department of Agriculture, Jamaica.

former arable as a result of early thinning. In East Anglia, therefore, these species are just as susceptible as pines to killing by *F. annosus*.

Some plantations established about 1905 are sufficiently old to show advanced stages of butt rot caused by *F. annosus* in Douglas fir, larch, and spruce. Butt rot is not found in pines of this age, however, and has only been seen in a few trees about 100 years old. Douglas fir and larch show incipient rot when 25–30 years old, in marked contrast to pines. These observations agree with some made by Peace (4) on the incidence of *F. annosus* butt rot in conifers of various age groups.

DEVELOPMENT OF BUTT ROT.

In East Anglia butt rot in Douglas fir, larch, and spruce is preceded by root infections similar to those described for killing of pines. Stumps created by thinning are colonized by *F. annosus* and act as centres of infection. Relatively small living roots in contact with stump roots are generally infected first, there is very little resin exudation, and *F. annosus* grows rapidly in all tissues until it reaches roots of about 2 cm. diameter. Thereafter rapid growth occurs in the central wood only and the parasite may be almost checked in the outermost wood and bark (Fig. 1). However, the fungus sometimes grows superficially on the root in

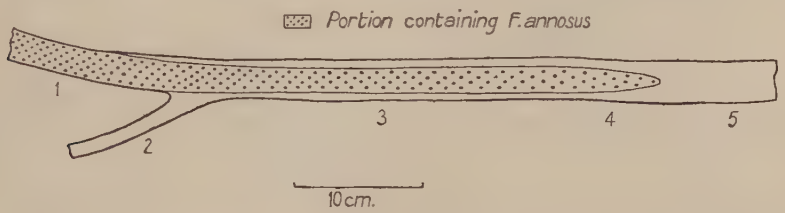

FIG. 1. Root infection preceding butt rot: diagrammatic section of larch root invaded by *F. annosus*. 1. Wood very rotted, yellow; bark dead, brown; *F. annosus* hyphae abundant in both. 2. Small living root. 3. Most of the wood resinous, red-brown, hyphae abundant; outermost wood healthy; bark discoloured, bright red in parts, otherwise healthy, hyphae local on surface only. 4. As last, but smaller region of central wood with hyphae. 5. Whole root healthy.

advance of its penetration into the bark. Resin exudation remains slight and the wood is seldom very resinous, although often discoloured: larch roots, for instance, are frequently bright red at this stage. Small branch roots may be produced by unaffected tissues some 20–30 cm. behind the region where *F. annosus* has penetrated the inner wood. This proliferation of roots helps to explain the lengthy survival of trees with extensive rot.

These early stages of rot, found in trees 20–30 years old, contrast with the condition found in very young trees, where rapid growth of *F. annosus* in one or more roots leads to girdling of the stem base and thus to death. Here the parasite frequently grows faster in the bark than in the wood. Trees over 25 years old are seldom killed outright owing to an increased resistance of the bark of roots to *F. annosus*. The sequence of events just described for Douglas fir, larch, and spruce contrasts markedly with that in pines of comparable age which frequently check growth of the parasite in all tissues by abundant resin production and only then proliferate new roots.

In later stages of rot, when the fungus has almost reached the butt, a conspicuous layer of resin is often formed between the inner and outer wood (Fig. 2). Here, white healthy wood contrasts strikingly with yellow rotted wood just inside. If only one subsidiary root was initially infected, the main root bearing it has in this region a relatively small rotted portion, which is often eccentric in position. If several subsidiary roots were infected, the rotted portion tends to be large and more or less central. The position of the rot in roots approaching the butt determines that of the rot in the butt itself; in still later stages cavities in the butt can be traced to the roots in which rot originated.

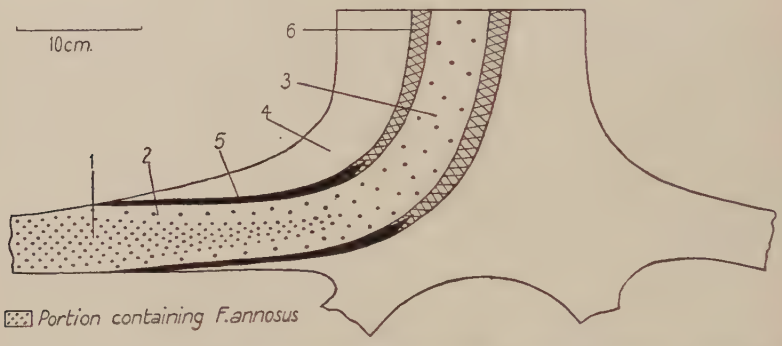

Fig. 2. Early stage of butt rot: diagrammatic section of lower butt of Douglas fir, with *F. annosus* entering from a lateral root. 1. Wood extensively rotted, yellow. 2. Wood partially rotted, yellow-brown. 3. Wood with incipient rot, red-brown. 4. Wood healthy, white. 5. Resin layer. 6. Wood resinous, deeply stained.

In one plantation, some 10 years after the first infections took place, *F. annosus* had ascended over 2 metres in the trunks of many 40-year-old spruces. A more direct observation of the growth rate of the parasite was made by Rennerfelt (5), who inoculated spruce stems and obtained a maximum growth of 1·3 m. in 2 years. This is comparable with the growth rate of 0·6 m. per year frequently recorded in pine roots in former arable soils [Rishbeth (9)] and suggests that spruce heartwood has an equally low resistance to penetration by *F. annosus*. Cartwright (1) has shown by laboratory tests that the resistance of larch heartwood to fungal attack decreases progressively towards the centre.

Advanced stages of rot were investigated mainly in 40-year-old spruce, but were also seen in a small oak (*Quercus robur* L.). In one spruce a pure growth of *F. annosus* extended from the butt well up into the trunk, and in this instance secondary fungi had been checked in the rotted root at an *F. annosus* zone-line [Rishbeth (8)]. More commonly *F. annosus* had been replaced in much of the rotted butt by other fungi, which had entered through roots. At the base of the butt, fungi such as *Trichoderma viride* Pers. ex Fr. and *Torula ligniperda* (Willkom) Sacc. were often dominant, whereas *F. annosus* was absent or confined to a narrow strip of wood. Higher up, secondary fungi were still usually present; *F. annosus* had been replaced to a greater or less extent and was sometimes confined to the apical region of rot. Such trees often lacked external symptoms of disease and

remained alive even though some three-fifths of the basal wood was rotted. Some, however, had developed very thin crowns and would probably have died within a few years.

One spruce butt with three conical regions showing different stages of rot (Fig. 3) provided interesting information about the course of succession. In the

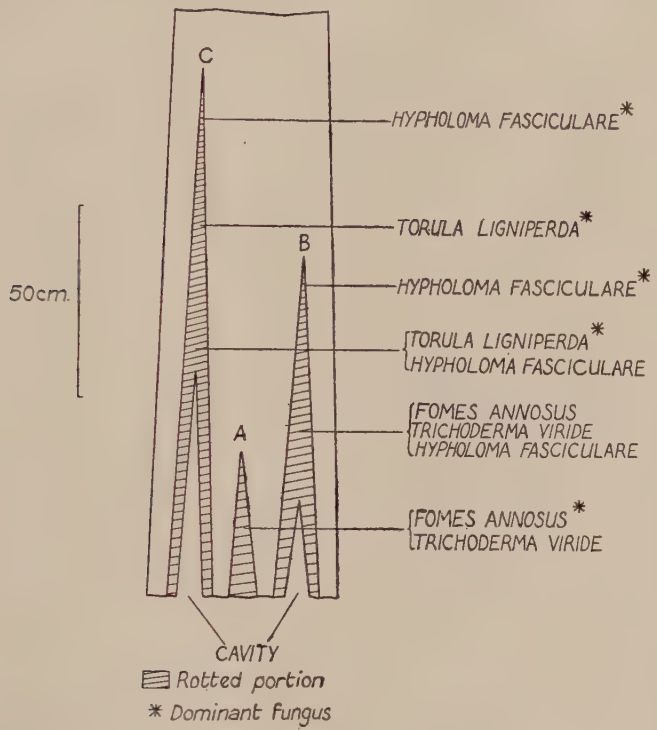

FIG. 3. Late stage of butt rot: diagrammatic section of spruce butt with three rotted regions (A–C), showing some of the fungi present.

least rotted region, A, *F. annosus* was dominant and *T. viride* also present. In region B, *F. annosus*, *T. viride*, and *Hypholoma fasciculare* (Huds.) Fr. were present at the base and *H. fasciculare* alone present at the top. *F. annosus* was absent in region C where rot was most advanced: *Torula ligniperda* was dominant at the base, with *H. fasciculare* also present, whereas the latter fungus was dominant at the apex of the rot. Laboratory experiments showed that *Trichoderma viride* and *Torula ligniperda* can replace *F. annosus* in wood, but may in turn be replaced by *H. fasciculare*. In the roots of the tree just described *F. annosus* was abundant in rotted regions continuous with those of the butt. Butt rot was almost certainly initiated by *F. annosus*, therefore, but in two regions *H. fasciculare* eventually became dominant. Replacement of *F. annosus* by other fungi in the rotted roots may have been less extensive because conditions were different there.

THE RELATION OF BUTT ROT TO THINNING.

Although the relation of stumps to butt rot is sometimes mentioned in the literature, only one paper records the effect of thinning on the incidence of this disease. Hepting and Downs (2), working in North Carolina, give figures for the amount of butt and root rot caused by *F. annosus* in plots of *Pinus strobus* on former agricultural land, examined 26 years after the first thinning. The plots, which had been thinned four times, were surrounded by strips also thinned to provide the same crown conditions along the edges as in the centre. In four thinned plots an average of 60 per cent. of the trees were found to contain *F. annosus*, and the corresponding strips had 37 per cent. The presence of *F. annosus* on stumps in the thinned plots was noted. In comparable unthinned areas only 4 per cent. of the trees contained *F. annosus*. *F. annosus* may well have spread by root contact outside the strips during the experiment: with a growth rate of 0·6 m. per year, already quoted for arable land in East Anglia, the parasite might in places have penetrated 16 m. or so into the unthinned areas. Some at least of the trees growing there might have been infected in this way. Even if this was not the case, the contrast between thinned and unthinned areas is striking, and there seems little doubt that butt rot developed mainly as a result of infections from stumps containing *F. annosus*.

The observation that trees are usually affected by butt rot in groups [Hiley (3)] strongly suggests that sources of infection are localized. Such localization would be expected if infection originated from stumps containing *F. annosus*, but not if it originated from spores or mycelium in the soil. In the East Anglian investigation all butt rot caused by *F. annosus* was found to be associated with infected stumps.

DISCUSSION.

The observations recorded indicate that, to understand the development of butt rot by *F. annosus*, study of really early stages is essential. Many previous accounts deal with relatively late stages in which it is often possible to determine which main root was infected first but in which the mode of initial infection is obscure. This must in part account for the wide divergence of opinion about the mode of infection. The task of studying early stages, apparently rendered difficult by lack of crown symptoms, is relatively easy once it is realized that the critical first infections occur on living roots immediately around stumps containing *F. annosus*. Field investigations provided no support for the contention that entry occurs only through weakened or dead roots: early stages of infection were found on roots of normally healthy appearance. Experiments [Rishbeth (7)] suggest that *F. annosus* is unlikely to invade dead roots because of its limited capacity to compete with other fungi.

The course of fungal succession described for spruce indicates that *F. annosus* may be replaced by other fungi soon after rot appears in the butt. Clearly the absence of this parasite at the base of a well-rotted conifer trunk does not necessarily indicate that another fungus caused the initial damage.

The evidence quoted strongly suggests that butt rot develops as a result of

thinning. Analogy with tree-killing by *F. annosus* suggests further that any forest operation producing stumps will tend to be followed by butt rot. On former woodland sites, for instance, both manifestations of parasitic attack may appear, death of young trees arising from early root infections and butt rot arising from later root infections when trees are older and more resistant.

Although butt rot caused by *F. annosus* is associated with a variety of soil and climatic conditions, some widely different from those found in East Anglia, it is perhaps helpful to suggest ways in which various factors may affect the disease. The stage at which butt rot develops will depend on the history of the site: the presence of infected stumps from a previous crop of conifers will tend to produce an early outbreak whereas, on sites planted for the first time, trees will become rotted only after thinning, for example. Severity of butt rot will be determined partly by the frequency of stumps containing *F. annosus*. This in turn will depend not only upon the total number of stumps in the site but upon the population of *F. annosus* spores in the air at the time of felling [Rishbeth (8)]. The number of infections occurring on living roots around stumps containing *F. annosus* will also influence severity; this is determined largely by the type of soil microflora and tends to be great on formerly cultivated and alkaline soils, for instance. Butt rot may increase in severity during a succession of coniferous crops owing to an increase in the number of infected stumps. This condition is most likely to occur on alkaline soils where the rate of replacement of *F. annosus* by other fungi in stumps is slow. On most acid soils, however, replacement of *F. annosus* occurs rapidly enough to prevent a cumulative increase in root disease inoculum.

Since *F. annosus* can tolerate relatively low oxygen tensions [Zycha (10)], it may well have an advantage over competing fungi in badly aerated soils: the prevalence of the parasite in some waterlogged sites, for instance, may possibly be explained in this way. Finally, resistance to parasitic attack will depend on the species, age, and numerous interacting site factors. Such resistance will not necessarily be possessed equally by all parts of the root system: in some sites, for instance, sinker roots may be weaker than laterals owing to poor soil aeration, whereas in others sinker roots may be stronger, owing to a better water supply.

ACKNOWLEDGEMENTS.

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NORWAY SPRUCE[1] SPACING PLOTS AT WESSLING, BAVARIA

By W. H. GUILLEBAUD

(*Forestry Commission*)

SUMMARY.

The paper discusses the results obtained to date from a unique series of Norway spruce spacing plots established in 1910 in Bavaria. There is a series of ten plots covering initial spacings ranging between 3 ft. 7 in. and 6 ft. 7 in. and an eleventh plot, spaced at just over 13 ft., and interplanted 6 years later at $3\frac{1}{4}$ ft $\times$ $3\frac{1}{4}$ ft. The plots have only been twice thinned and have suffered no windfall in spite of their rapid growth.

The results of the latest assessment by Prof. Vanselow, in 1949, have been summarized in a recent German forestry journal, and in the present paper extracts from Vanselow's data have been converted into English units.

Although spacing has had no apparent effect on height growth, other factors such as B.H. girth, form of stem, branching, and average volume per tree show the expected response to increased spacing. There is some indication of a reduction in total yield to date with increasing spacing in the main series of plots. The plot spaced at 13 feet has many features of special interest, *inter alia* the death by suppression of 97 per cent. of the plants used to fill up.

Vanselow concludes that the optimum initial spacing for spruce on similar sites lies within the narrow range of 4 ft. 6 in. and 5 ft. 3 in. This accords closely with current Forestry Commission practice.

IN the September 1950 number of the south German forestry journal *Forstwissenschaftliches Centralblatt* Professor K. Vanselow has reported on a series of remarkable Norway spruce spacing plots at Wessling near the Ammersee, not far from the city of Munich.

The plots were established in 1910 with 2-yr. 2-yr. Norway spruce from the Halstenbek nurseries, and Vanselow, following what seems to be a common continental practice of reckoning the age of the plantation from seed, writes of it as 43 years old in 1949. For the purposes of the present summary, however, the year of planting is taken as the datum line and the age accordingly as 39 years at 1949, the date of the latest assessment.

The plots are remarkable on several counts:

1. Although the individual plots are large (about $1\frac{3}{4}$ acre each) the soil conditions as judged by subsequent examination, by the nature of the ground vegetation, and by the rate of growth of the trees, were quite exceptionally uniform. Only one plot out of the whole series of twelve plots has had to be rejected on the score of a soil difference. This reject plot happens to be the closest of all the spacings (1·0 metre $\times$ 1·0 metre or 3 ft. 3 in. $\times$ 3 ft. 3 in.).

2. Omitting the 1-metre plot there is a series of ten plots ranging in spacing from 1·1 metre (3 ft. 7 in.) to 2·0 metres (6 ft. 7 in.), the spacing increasing by $\frac{1}{10}$ metre (4 inches) in each successive plot. In addition to this main series of plots the Forestry staff very wisely added one further plot at the extremely wide spacing

[1] *Picea abies* Karst.

of 4 metres (13 ft. 2 in.). After 6 years' growth this plot looked so miserable that the foresters despaired of its ever forming canopy and beat the whole of it up at a $3\frac{1}{4}$ ft. $\times 3\frac{1}{4}$ ft. spacing. The subsequent development of the original trees in this plot and the fate of the beat-ups are among the most interesting features in the whole experiment.

3. The whole series has been preserved intact up to the present date. Although the plots were deliberately left untouched for 33 years, they suffered no damage from either wind or snow-break, and there have been no disturbances from insect or fungus attack to upset the data.

4. The average height of 64 feet at 39 years and upper height of 69 feet places the plots at about the mean of Quality Class I.N.S. in our British Yield Tables. This rapid rate of growth lends additional weight and interest to the data.

History.

The spruce was planted on land which had previously been under the plough but was under grass at the time of establishment. The plots were first assessed in 1941 at the age of 31 years, first thinned in 1943, thinned again in 1948, and remeasured in 1949. The first thinning was of the nature of a B-grade, removing mainly dead, dying, diseased, suppressed trees and whips; the second thinning was heavier, more or less of a C-grade, and aimed at breaking up the groups that had formed. It was part of the plan that none of the trees should be pruned.

The major results may be summarized as follows:

Number of Stems per Acre.

Table I shows the position after the second thinning.

TABLE I. *Stocking per Acre*

Original spacing	*No. planted per acre*	*No. dead before 1st thinning*	*No. removed in the two thinnings*	*No. standing at age 39 years*
3 ft. 7 in.	3,345	1,600	985	760
4 ft. 3 in.	2,395	695	990	710
4 ft. 7 in.	2,065	420	950	695
4 ft. 11 in.	1,800	270	795	735
5 ft. 3 in.	1,580	190	665	725
5 ft. 7 in.	1,400	140	535	725
5 ft. 11 in.	1,250	135	485	630
6 ft. 3 in.	1,120	110	390	635
6 ft. 7 in.	1,010	70	340	615
13 ft. 2 in.	255	20	..	235
Interplanting	3,795	3,140	655 (died)	100

The high death-rate which is very pronounced in the closer spacings was largely the result of leaving the plots so long unthinned. As regards the present main crop, although the combined effect of deaths and thinning has been to even out the stocking to a remarkable degree, the influence of spacing is still apparent in

the lower stocking of the three most widely spaced plots in the main series. In the 13-foot spacing, whereas all but about 20 of the original trees still survive, the later interplanting fared very badly; of the 3,795 plants put in only 100 survived in 1949 and many of these were moribund—a good illustration of the fate of delayed beating up.

Height Growth.

The mean height at 39 years of age of the Dominant trees (Kraft's Class II) was 68 feet in the main series of plots, and 70 feet in the 13-foot plot. Variations between the means of the plots was only ± 3 feet. This is further evidence to support the generally accepted view that in conifers height growth is little, if at all, affected by the amount of growing space given.

It is interesting to note that in 1949 about a dozen of the 100 survivors of the interplanting of the 13-foot plot were then growing vigorously and showing definite promise of entering the main canopy. These trees put on shoots averaging 2 ft. 6 in. a year during the past eight years.

Crown Development.

In the main series of spacings the branches were dead to a uniform level of 39 feet above ground, but in the 13-foot spacing plot in which canopy was only just forming, the height to the first live branch was only 26 feet. The proportion of the tree length occupied by crown was 44 per cent. in the main series of plots, and virtually unaffected by spacing, but 60 per cent. in the 13-foot plot.

Vanselow also determined, shortly after the second thinning, the Degree of Shading (*Beschirmungsgrad*), which he expressed as the percentage of the area occupied by the tree crowns. This was determined partly by measurement from the ground and partly from sample vertical photographs on which the area of open sky was measured. The degree of shading was found to average 69 per cent. in the main series of plots, the percentage gradually but consistently increasing from the closest to the widest spacing. The corresponding figure for the 13-foot plot was 87 per cent.

Breast Height Girth in 1949.

Some of the data are given in Table II.

TABLE II. *Quarter Girth at Breast Height*

Spacing	3 ft. 7 in.	4 ft. 3 in.	4 ft. 11 in.	5 ft. 3 in.	5 ft. 7 in.	5 ft. 11 in.	6 ft. 3 in.	6 ft. 7 in.	13 ft. 2 in.
Average Q.G.	5¼	5½	5½	5½	5½	5¾	5¾	6	8¼
No. of trees per acre of 7½ in. Q.G. and over.	66	70	64	90	67	100	102	127	177

Girth is not greatly affected until the original spacing exceeds 5½ feet but from then on the effect is evident, not only in the mean girth but also in the number

of relatively large trees per acre. The 13-foot plot with a mean Q.G. of 8¼ inches demonstrates the effect of almost full growing space.

Stem Form.

When the experiment was first assessed in 1941 the trees in the closer-spaced plots were very substantially less tapering than those at the wider spacings. The latest assessment showed that though differences were still apparent the form of the trees in the more widely spaced plots had improved considerably in the 8-year interval. In the 13-foot plot the trees were still very tapering.

Volume Production.

Table III sets out the main crop volumes per acre at 39 years of age, thinning yields, and total production to date.

TABLE III. *Volume Production (Cu. ft. Quarter Girth per Acre)*

Spacing	*Volume 1949*	*Thinning 1943*	*Thinning 1948*	*Total thinning +5% for stumps*	*Total yield to date*
3 ft. 7 in. (1·1 to 2·0 metres)	4,570	760	440	1,260	5,830
4 ft. 3 in. (1·1 to 2·0 metres)	5,000	740	550	1,360	6,360
4 ft. 7 in. (1·1 to 2·0 metres)	4,840	610	430	1,090	5,930
4 ft. 11 in. (1·1 to 2·0 metres)	4,980	450	420	910	5,890
5 ft. 3 in. (1·1 to 2·0 metres)	4,700	490	370	910	5,600
5 ft. 7 in. (1·1 to 2·0 metres)	4,750	430	300	760	5,520
5 ft. 11 in. (1·1 to 2·0 metres)	4,620	310	290	640	5,260
6 ft. 3 in. (1·1 to 2·0 metres)	4,630	250	270	550	5,180
6 ft. 7 in. (1·1 to 2·0 metres)	4,900	170	210	400	5,300
13 ft. 2 in. (4 metres)	3,830	0	20	20	3,850

It will be noted that in the 1·1 to 2·0 metre spacing series the standing volumes in 1949 were all practically level at round about 4,700 cu. ft. per acre. Only the 4-metre plot shows a marked drop to 3,800 cu. ft. On the other hand, as might be expected, the yields from the two thinnings decrease from about 1,300 cu. ft. per acre in the closest spacings to 400 cu. ft. in the 6½-foot plot, and to virtually nil in the 13-foot plot.

As regards the total yield to date, the plots seem to fall into three groups: spacings below 5 feet which average about 6,000 cu. ft. per acre, the 5- to 5½-foot plots yielding about 5,600 cu. ft. per acre, and the 6- to 6½-foot plots with about 5,300 cu. ft. per acre. As the plots were not replicated it would be unsafe to lay too much stress on these apparent differences, but the trend is interesting as indicating that wide spacing may lead to some reduction in total yield.

The plot spaced at 13 feet has produced a yield of 3,800 cu. ft. per acre (100 cu. ft. per acre per annum), which is not to be despised, although the trees are tapering and heavily branched. The average volume per tree in 1949 was 16·6 cu. ft., as compared with an average volume of 8·2 cu. ft. in the 6½-foot spacing plot.

The current annual increment over the past 8 years in the main series of plots has averaged 217 cu. ft. The average for the closer-spaced plots (3 ft. 7 in. to 4 ft. 11 in.) was 221 cu. ft. and that of the wider spacings (5 ft. 3 in. to 6 ft. 7 in.) was 212 cu. ft., though whether this small difference is statistically significant, as Vanselow maintains, seems more than doubtful. Of greater interest is the high increment of 275 cu. ft. put on by the 13-foot spacing plot. Vanselow ascribes this to the larger crowns and greater root development of the individual trees and to the fact that these were not affected by a severe drought in 1947 which reduced growth in the other plots. As soon as complete canopy has formed in the 13-foot plot and the lower branches die off it seems reasonable to assume that the current volume increment will tend to approximate to that of the other plots, so that it is always likely to remain behind in total production though not in the size of the individual trees.

Branching.

Measurements carried out in 1941 showed that in the 13-foot plot the dead branches had an average length of 5 ft. 7 in. as compared with an average length of 1 ft. 10 in. in the main series of plots, and of only 7 inches in the 3 ft. 3 in. and 3 ft. 7 in. plots. But the longer the branches the stouter they are, and while in the 13-foot plot the branches were 0·84 inch in diameter at the base, in the two closest spacings the diameter was only 0·3 inch.

Vanselow concludes that if it is desired to produce good quality timber without recourse to artificial pruning a spacing of 5 ft. 3 in. (1·6 metre) is the widest permissible.

Cost.

Vanselow does not discuss the cost question in any detail beyond pointing out that as far as establishment costs are concerned these are in proportion to the number of plants planted. Taking 5 ft. 3 in. as a standard planting distance as 100, the ratios are as follows:

3′ 3″	*3′ 7″*	*3′ 11″*	*4′ 3″*	*4′ 7″*	*4′ 11″*	*5′ 3″*	*5′ 7″*	*5′ 11″*	*6′ 3″*	*6′ 7″*	*13′ 2″*
256	221	178	151	131	114	100	89	79	71	64	16

When the plots were first thinned (in 1943) there was a good local demand for small poles and the large outturn from the closer spacings was evidently very profitable. Vanselow points out, however, that if the first thinning had not been delayed, little of the produce from these plots would have been saleable.

CONCLUSIONS.

Vanselow concludes that considerations of cost and stability alike rule out spacings below $4\frac{1}{2}$ feet, and that, assuming that the object of management is to produce the maximum volume of high quality timber, the spacing should not exceed $5\frac{1}{4}$ feet, given growth conditions approximating to those at Wessling. In other words, about 5 ft. × 5 ft. is considered to be the optimum planting distance for Norway spruce on good soils. Vanselow adds that the cost factor, or shortage of plants or labour, may, at the present time when large areas have still to be

replanted, justify wider planting distances than 5¼ feet. He does not, however, venture any suggestion as to how far it might be permissible to go.

By somewhat of a coincidence the same issue of the *Centralblatt* contains an article by the well-known Swedish forester, Dr. Bertil Lindquist, on silvicultural problems in Sweden, in the course of which Lindquist mentions the spacing question. On economic grounds he recommends a spacing of between 5 ft. and 5 ft. 9 in. on good soils in south Sweden, increasing to from 5 ft. 9 in. up to 8 ft. × 8 ft. on the poor soils and hard climate of north Sweden. Lindquist adds, however, that such wide spacing in north Sweden is only permissible on the assumption that high-quality seed of controlled origin is employed for raising the plants. With ordinary mixed seed, the spacings would have to be closer to allow for adequate selection.

Our Forestry Commission practice is to use a spacing of 5 to 5½ feet for Norway spruce and of 5½ to 6 feet for Sitka spruce (*Picea sitchensis* Carr.)

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A CONTRIBUTION TO THE KNOWLEDGE OF THE GENUS *EVETRIA* HBN. (LEPIDOPTERA, TORTRICOIDEA)[1]

By MYLES CROOKE

(*Forestry Department, University of Aberdeen*)

SUMMARY.

This paper discusses the species belonging to the genus *Evetria* Hbn. which are of interest and importance in British forestry. These four species are: *E. buoliana* Schiff., the pine shoot moth; *E. turionana* Hbn., the pine bud moth; *E. resinella* L., the pine resin-gall moth; and *E. purdeyi* Durr., the pine leaf-mining moth. The main morphological features of all stages of each of the four species are described. Details of the biology, the damage inflicted to individual host trees, and the forest status of each of the species are given and suggestions for control, based mainly on silvicultural techniques, are advanced.

INTRODUCTORY.

THE genus *Evetria* Hbn. (Lepidoptera, Tortricoidea) has for long been of interest to foresters because of the damage inflicted to young pinewoods by a number of its members. Amongst these the best known is *E. buoliana* Schiff., the pine shoot moth, which has been recognized as one of the most serious primary pests of young pinewoods in Europe for well over 100 years and which more recently, as an imported pest, has attracted much attention in North America. Other species recorded as forest pests on the Continent are *E. turionana* Hbn., *E. resinella* L., and *E. duplana* Hbn.

In the British Isles the species *E. buoliana*, *E. turionana*, and *E. resinella* are regarded as being of forest significance. In particular, the severe outbreak of *E. buoliana* which occurred in East Anglia in the 1920's and 1930's brought the genus into prominence and in more recent years the damage caused in Yorkshire and Lincolnshire by *E. purdeyi* Durr., a species which had been regarded as very rare and of no economic importance, has again underlined the destructive potentialities of this group of moths.

E. buoliana, which does not occur in the north of Scotland, has been intensively investigated both in Europe and in North America, but the two species *E. turionana* and *E. resinella* which occur commonly in the north of Scotland have not been so fully investigated hitherto. The aim of the investigation of which this paper is the result was, therefore, to elucidate in as great detail as possible the biology and ecology of these two species. In addition, comparative studies were conducted on *E. buoliana*, which yielded some new data, and on *E. purdeyi*, of which no account has previously been published in any generally available form.

GENERAL ACCOUNT OF THE GENUS.

The genus *Evetria* Hbn. is placed by Kloet and Hincks (16) in the family Eucosmidae of the phylum Tortricoidea (Lep.), corresponding to the position

[1] Based on parts of a thesis for the degree of Ph.D., of the University of Aberdeen, entitled 'The Ecology and Silvicultural Importance of the Genus *Evetria* Hbn. (Tortricoidea, Lep.).'

designated it by Meyrick (18) in the family Epiblemidae of the phylum Tortricina (Lep.). The generic name *Evetria* Hbn. is synonymous with *Rhyacionia* of the same authority, whilst in the literature the generic names *Retinia*, *Coccyx*, *Grapholitha*, and *Tortrix*, now superseded, are sometimes met with.

The genus contains about forty species, all of which are found in temperate regions mainly of the northern hemisphere throughout Europe, Asia Minor, Siberia, Japan, and North and South America. The following nine species are recorded from the British Isles: *pinicolana* Dbld., *buoliana* Schiff., *pinivorana* Zell., *turionana* Hbn., *resinella* L., *posticana* Zett., *logaea* Durr. syn. *duplana* Meyr.—a casual immigrant and adventive species—*purdeyi* Durr., and *sylvestrana* Curt. All the above species are recorded from the continent of Europe as well as the British Isles with the exceptions of *E. pinicolana* and *E. purdeyi*. The latter species is presumed by Meyrick (18) to have been imported, but there is no evidence to support this view.

The larvae of the moths of the genus *Evetria*, with one exception, feed on *Pinus* spp. in needles, shoots, buds, bark, and galls. Young trees are most usually selected as hosts and it is on them that the greatest amount of economic damage is inflicted. Many species, particularly those in North America, are restricted to one or two species of the genus *Pinus*, but this is by no means true of the European representatives. For example, *E. buoliana* has been recorded by Vilmorin (21) as occurring on more than twenty species of pine, and Wolff and Krausse (22), Altum (1), Girard (15), and Busck (6) also record *E. buoliana* on a number of *Pinus* species.

The single exception to the above rule is a North American species *E. taxifoliella* Busck which utilizes as its host plant *Pseudotsuga glauca* Mayr.

The normal life-cycle in the genus *Evetria* is one generation per annum with hibernation taking place in the larval stage. In some species, for example *E. resinella*, the generation is extended to cover 2 years, both winters being passed in the larval stage, whilst in the southern regions of the generic range species and varieties which produce two generations per annum are known. For example, Bodenheimer (3) records a variety of the pine shoot moth, *E. buoliana* var. *thurificana*, which in Palestine has a life-cycle of this type.

PREVIOUS LITERATURE.

In the past numerous references have been published to the genus as a whole and to *E. buoliana* in particular. Since 1776, when Schiffermiller (20) first described *E. buoliana*, naming it after the Viennese naturalist, Baron Buol, many scientific journals have included papers on this and other related species. In addition, every text-book on forest entomology devotes a section to this group of moths. The wide range of countries represented in the literature—Germany, the Scandinavian countries, Russia, France, Italy, Holland, Great Britain, and, more recently, the United States of America, Canada, and the Argentine—and the regularity with which contributions on this subject have appeared over the years well exemplifies the importance which has been and continues to be placed on this group of forest pests.

Although the earlier papers are of value for their descriptions of the life-cycles and forest status of the species and for the control methods, mostly mechanical but to some extent biological, used against them, many of the contributions are repetitive in character and none of them is in great detail. All the most important references have been produced in the last 30 years. Foremost amongst these are Gasow's (13, 14) papers of 1925 which, for the first time, described in detail the egg-laying and early larval life of *E. buoliana*. By demonstrating that the first instar larva, and the second instar larva for part of its stadium, are not enclosed in the bud tissues as had previously been thought, Gasow indicated the possibility of using chemical control methods against this pest. His work was corroborated by De Gryse (10), who in 1932 again stressed that, to be successful, chemical control must be synchronized with the free-moving stages indicated above. The most important British paper is that by Brooks and Brown (4), who made a detailed study of *E. buoliana* in East Anglia and published their findings in 1936. The value of this original contribution is enhanced by its extensive bibliography. A similarly detailed paper describing *E. buoliana* under Swedish conditions was published by Butovitsch (7) in 1937.

Busck (5) first recorded the importation of *E. buoliana* on nursery stock from Europe into North America in 1914. A series of papers after that date recorded the spread of the pest on that continent despite the application of intensive control measures. In the American literature interest centres on the development of chemical control techniques such as those recorded by Friend and West (12), McDaniel (17), *et alia*.

Publications on *E. turionana* and *E. resinella*, apart from the general descriptions found in text-books, are few. The only contributions worthy of note are the two short papers published by Cameron (9, 8) in Britain on these two species in 1940 and 1939 respectively.

MORPHOLOGY.

I. *Adults*.

The following descriptions are based, with amendments, on those of Barrett (2), with the exception of that of *E. purdeyi*.

(*a*) *E. buoliana*. Wingspan 15–23 mm. Antennae grey, brown towards the base; palpi and head lemon above, orange-red at sides; thorax orange-red in front and grey behind. Patagia orange-red at the base, greyish-white at the apex. Forewings rather elongated, costa flatly arched, apex bluntly rounded, hind margin curved; bright orange-red with paler shades especially towards the dorsal margin which is dull yellow; the whole area of the wing variegated with irregular silvery-white or pale yellow transverse bands; cilia silvery-grey with a black basal line. Underside of the forewings smoky brown. Hindwings dark fawn with white cilia bearing a black basal line; underside smoky brown. Abdomen grey with a very slight pinkish tinge on the caudal tuft.

(*b*) *E. turionana*. Wingspan 11–18 mm. Antennae dark brown, palpi and head yellow-brown; thorax ferruginous brown. Patagia dark brown, tipped with grey behind. Forewings elongated, costa nearly straight, apex and hind margin

rounded; pale silvery-grey, heavily dusted and cross-striped from the base with brown, shading in the middle to pale tawny and at the apex to rusty red, still crossed by silvery-brown slender stripes which originate in twin costal brown spots; cilia greyish-white, tipped with black. Underside of the forewings lustrous grey-brown, the costa dotted with white. Hindwings grey, dusted with brown; cilia white; underside grey, lighter than that of the forewings. Abdomen pale shining grey with a drab caudal tuft.

(*c*) *E. resinella.* Wingspan 15–22 mm. Antennae dark brown; palpi, head, and thorax deep brown, the latter dusted at the sides with white. Patagia coloured as the thorax, tipped with grey. Forewings elongated, costa gently arched, apex bluntly angulated, hind margin rather shortly rounded off at the anal angle; pale silvery-grey sprinkled with numerous brown scales which, at intervals, are condensed into irregular transverse bands; the apical area is set off with well-marked costal spots, the largest of which is at the apex; cilia shining brown. Underside of the forewings leaden-grey, dotted with black on the costal margin. Hindwings smoky brown with white cilia; underside leaden white. Abdomen dark brown, dusted with grey, especially at the sides, the apex ochreous.

(*d*) *E. purdeyi.* Wingspan 8–12 mm. Antennae brown; palpi, head, and thorax grey. Patagia brown, tipped with grey. Forewings elongated, costa arched and apex and hind margin bluntly rounded; dark brown with irregular greyish markings which, near the middle, coalesce to produce several very fine grey transverse lines, the apical third ferruginous; cilia grey with a black basal line. Underside of the forewings very pale silvery-brown. Hindwings leaden grey, underside similar. Abdomen shining grey.

(*e*) *Sexual Differences.* Exclusive of genitalial characters (described below) the distinction of the sexes of *Evetria* spp. can be determined from the relative size and general appearance of the individuals. On average, the females are more stoutly built and have a larger wingspan than the males. The most useful feature is that of abdominal width, the females in a species having a width of almost twice that of the males. Wingspan measurements, although not absolute, afford confirmatory evidence.

TABLE I. *Comparison between the Wingspans and Abdomen Widths of the Sexes of* Evetria *spp.*

Species	*Sex*	*Number of individuals measured*	*Wingspan (mm.)*			*Width of abdomen (mm.)*		
			Average	*Largest*	*Smallest*	*Average*	*Largest*	*Smallest*
buoliana	Female	48	20·4	23	18	2·0	3·0	1·5
	Male	37	17·0	19	15	1·0	1·4	0·8
turionana	Female	29	15·0	18	14	1·4	1·5	1·3
	Male	41	13·0	15	11	0·7	1·0	0·5
resinella	Female	24	18·7	22	16	1·6	2·1	1·4
	Male	44	16·0	17	15	0·97	1·2	0·8
purdeyi	Female	17	10·8	12	10	0·86	1·1	0·7
	Male	10	8·5	9	8	0·45	0·6	0·3

In addition, the general shape of the abdomen is characteristic for each sex. In the males it is parallel-sided with a gently rounded apex. In the females it is broadest in the middle and tapers to a fairly fine point at its apical extremity. These differences in shape and size of the abdomen are less appreciable after the female has deposited her eggs, and these characters can be used with certainty as sex determinants only for newly emerged individuals.

(*f*) *The Genitalia.* The genitalia of the sexes are of value in determining sex of individuals in a macroscopic examination and, when examined microscopically, provide absolute characters for determining the species of any individual. They are of particular value in identifying old or damaged specimens where characters more normally used may be missing. The nomenclature followed in the descriptions is that adopted by Pierce (19).

(i) *E. buoliana.* Male. Valvae with the cucullus not greatly expanded and only slightly wider than the arm; emarginate below the cucullus on the outer margin. Uncus rudimentary, produced into two rounded points, adorned with strong hairs; socii, round hairy pads. Aedoeagus cardinate, large, with an obtuse point, curved.

Female. Ovipositor flattened, angular. Ostium wide. Ductus bursae long, fine. Bursa delicate, without signa.

(ii) *E. turionana.* Male. Valvae short, constricted before the cucullus which is thus wider than the arm. Uncus rudimentary, rounded, hairy; socii, long and drooping. Aedoeagus cardinate, relatively smaller than in the preceding species, curved.

Female. Ovipositor flattened, wide. Ostium with inside tube and small sac extension. Bursa with signum pilleate.

(iii) *E. resinella.* Male. Valvae with large cucullus, very deeply and widely emarginate; sacullus produced into an angular plate. Uncus articulated but not produced, hairy; socii, long and drooping. Aedoeagus cardinate, fairly large, curved.

Female. Ovipositor flattened, rounded, wide. Ostium with heavy plate. Ductus bursae short, with thickened inside tube. Signa two, pilleate.

(iv) *E. purdeyi.* Male. Valvae long, very narrow before the cucullus; sacullus forming a right angle. Uncus rudimentary, forming a small point; socii absent. Aedoeagus large, cardinate.

Female. Ovipositor flattened, rather angular. Ostium with rounded anterior plate. Ductus bursae with thickened inside tube. Signa two, long, thin, curved. Bursa copulatrix with very fine irregular pattern of grooves on the walls.

II. *Eggs.*

The eggs of *Evetria* spp. are all of similar type and differ from species to species only in size. They are oval, or sometimes almost circular, in outline and flatly convex and scale-like in shape. The shell is formed of a colourless, transparent material and has an irregularly reticulated surface, the reticulations being most

commonly five- or six-sided. Within the shell is the egg, which is lemon-white and opaque, and circular or oval in outline.

TABLE II. *Average Egg Sizes of* Evetria *spp.*

Species	*Average length (mm.)*	*Average width (mm.)*
buoliana	1·1	0·9
turionana	0·7	0·5
resinella	1·2	0·9
purdeyi	0·7	0·5

III. *Larvae.*

The larvae of *Evetria* spp. are similar in general appearance. The abdominal prolegs, however, yield reliable features for the discrimination of the species, variation being found in the size, shape, and number of the crotchets, in the

TABLE III. *Comparison of Morphological Characters of Mature Larvae of* Evetria *spp.*

Character	*E. buoliana*	*E. turionana*	*E. resinella*	*E. purdeyi*
Length	Variable, 16–21 mm.	10 mm.	14 mm.	6 mm.
Body colour	Reddish-brown	Light brown	Light brown	Reddish-brown
Colour of head	Very dark brown	Black	Very dark brown	Brown
Colour of prothoracic and anal shields	Very dark brown	Very dark brown	Dark brown	Prothoracic shield brown, anal shield absent
Markings on dorsal surface of body segments	..	Two transverse reddish lines sometimes present	Two pairs of tubercles with hairs	..
Position of bristle-like hairs	Few, more frequent at anterior and posterior extremities	Mostly at anterior and posterior extremities	General over body	At anterior and especially posterior extremities
Number of crotchets per proleg	23–24	13–18	22–26	29–32
Chitin ring of proleg	Heavy, incomplete posteriorly	Fine, complete	Ill-defined posteriorly	Absent
Adornment of proleg	Four small bristles arising from very small tubercles	Four small bristles, not arising from tubercles	Five stout bristles each arising from a tubercle	None

appearance of the 'chitin-ring' at the base of the proleg, and in the arrangement of the bristles round the proleg. Confirmatory characters are provided by the general features of size, colour, and ornamentation of the larvae.

IV. *Pupae.*

The pupae of *Evetria* spp. are similar in general appearance and can be differentiated only by the characteristics of size and colour. The most obvious morphological feature, common to all species, is the presence of two transverse rows of small, stout, backwardly directed spines on the dorsal surface of each abdominal segment.

TABLE IV. *Comparison between Colour and Size of* Evetria *spp. Pupae*

Species	*Colour*	*Average length (mm.)*	*Smallest length (mm.)*	*Largest length (mm.)*	*No. measured*
E. buoliana	Dark brown thorax and wing cases, abdomen lighter	9·9	8·0	12·5	128
E. turionana	Dark reddish-brown	6·5	5·0	8·5	50
E. resinella	Black-brown	9·5	8·0	11·5	76
E. purdeyi	Lemon-brown	4·7	3·5	5·5	11

BIOLOGY AND FOREST STATUS.

The data presented below are the result of the integration of observations made from controlled breeding experiments carried out in Aberdeen, from periodic field examinations in Scotland and England, and, in the cases of *E. turionana* and *E. resinella*, from a statistical analysis of a sample plot area.

I. *E. buoliana.*

(*a*) *Life-cycle.* The dates of emergence of adult *E. buoliana* extend from late June until late August, peak emergence being in late July. The average duration of adult life is 18 days and the maximum duration recorded amongst caged individuals is 33 days. The flight period of the species, therefore, ranges between the limits of late June to the middle of September.

Oviposition by gravid females commences 1 to 2 days after emergence, reaches a peak from the 4th to 7th day after emergence, and thereafter rapidly declines during the remainder of the female's life. The eggs are deposited on current year's shoots. The duration of the egg stage varies between 16 and 25 days, the average being 18 days. Towards the end of this period the young larva is distinctly visible through the transparent shell. The larva emerges after biting a hole in the shell and for its first stadium, which lasts from 5 to 12 days and during which the larva measures 2 mm. in length, feeds on the base of a needle cluster under cover of a minute silken web. The needle sheath selected is usually one immediately

below the terminal bud whorl and never one more than 1 inch from the bud whorl. Immediately or shortly after the first ecdysis the larva migrates to the bud whorl, where it bores into a side bud under cover of another and larger silken web. Feeding continues on the bud tissues during the summer, and in this period the contents of one, two, or more buds, depending on size, are consumed. The web is progressively strengthened by the deposition on it of resin and excrement. In October hibernation takes place usually in one of the side buds of the whorl, the central bud remaining unattacked, but where the average size of the buds is small it may occur in the central bud. Resumption of activity takes place in April when the larva continues to feed on the bud tissues and, later, on the developing shoots. If the food supply of one whorl is exhausted the larva migrates to another whorl. The feeding during this period is voracious, particularly on the young shoots, and it is at this stage that the most serious damage is inflicted to the host tree. Feeding ceases from June onwards as the caterpillars reach maturity and pupation takes place in a hollowed-out bud or shoot. The duration of the pupal stage is variable up to a maximum of 30 days. When the adult is ready to emerge the pupa forces itself through the side of the bud or shoot, splits along the median dorsal line, and releases the imago.

(*b*) *Effect of Attack on Host Plant.* Observations made in East Anglia show that *E. buoliana* attacks *P. contorta* var. *Murrayana* Eng., *P. sylvestris* L., and *P. laricio* Poir. in that order of preference, whilst *P. radiata* D. Don. and *P. pinaster* are also attacked but less heavily. *P. strobus* L., adjacent to infested plantations, remained unattacked.

Feeding by an *E. buoliana* larva results invariably in a distortion of the subsequent growth of the host tree. Such distortion can be inflicted on either leading or lateral shoots but is more important on the former where a permanent defect of tree form can be produced. Such injuries can be classified into three types:

(i) Where all the buds of the whorl and the shoots derived therefrom are killed by the attack. In this case the attack terminates the growth of the shoot. Frequently, adventitious shoots arise from buds situated between a pair of needles but these are incapable of sustained growth, which is continued by a lateral branch from below the point of injury, resulting typically in a permanent, serious deformation of the tree's form.

(ii) Where the central bud or shoot derived therefrom is killed, without the destruction of all the lateral buds of the whorl. In this condition a lateral shoot replaces the leader and continues the height growth of the tree. The extent of permanent injury depends on the number and relative vigour of the remaining lateral shoots. If only one strong lateral shoot remains after infestation, height growth will be continued with only a slight bend in the stem. If two or more lateral shoots of approximately equal vigour remain, the struggle for dominance may last for many years and a permanent fork will be developed, eventually producing a multi-stemmed tree. Between these two extremes all variations of forking can occur.

(iii) Where the leading shoot is damaged at its base, recovers, regains dominance, and continues the height growth of the tree. This type of injury results in the

formation of the well-known 'posthorn' or 'bayonet' growth. The leading shoot, when injured, falls over at an angle and then curves strongly upwards to leave a well-marked and permanent bend in the main stem of the tree.

The leading shoot of a single tree may be attacked in successive seasons, intensifying the damage and resulting in the production of an extremely misshapen, bushy tree.

(*c*) *Forest Status.* One of the most outstanding features of attack by *E. buoliana* and, in fact, of attack by all the species of *Evetria* discussed in this paper, is that infestations are concentrated at or about a specific height on the host tree, corresponding to a flight zone favoured by the adult moths. This zone, for *E. buoliana*, is most usually from 5 to 6 feet and it is, therefore, young pine crops of between 4 and 10 years of age which are most seriously affected. An exception to this rule is that plantations of older age classes are sometimes subject to attack, as was evidenced by crops inspected in East Anglia of age approximately 25 years where 'posthorns' and forks were present at heights of between 20 and 25 feet. The effects of attack on these older trees were identical with those produced in young crops and it is believed that this is the first record of serious damage being caused at this unusual height although it has been recorded that *E. buoliana* can breed in limited numbers in the crowns of tall trees without causing any apparent serious damage. It is, in fact, such *nuclei* of infestation in old crops which most usually provide the initial populations of moths which spread to adjacent newly established crops.

No detailed figures of quantitative damage have been collected by the present writer. It is well known, however, that the percentage infestation is usually very high, and Brooks and Brown (4) state that in East Anglia 'only a small proportion of the leaders remain uninjured' in attacked crops. These authors record that in Swaffham and Wangford only 11·8 per cent. and 26·6 per cent. of leaders escaped uninjured after 8 years of attack. From this it is obvious that the level of damage is usually extreme.

The effect of attack by *E. buoliana* is more serious on crops of low vigour than on healthy crops, since (i) such crops with relatively small height increments take a longer period of years to pass through the main danger zone of height, (ii) buds and shoots on trees of reduced vigour are smaller than those on healthy trees and consequently more of them are required to satisfy the feeding potential of a single larva, and (iii) recovery from attack in a crop of reduced vigour extends over a longer period and is less complete than in a healthy crop.

From the silvicultural aspect the type of damage caused by the feeding of a larva of *E. buoliana* is of primary importance to the future composition of the crop. When forking occurs the eventual result is very often the production of a tree with a wide-spreading, heavily branched crown of typical 'wolf' type. Such trees observed in East Anglia in plantations which had suffered attack some 20 years previous to inspection were in many instances suppressing surrounding trees of desirable form which had either escaped attack or had made a good recovery. It appears that the damage caused by the production of a 'posthorn' on a main stem has been grossly over-estimated by previous writers. Admittedly such trees

will not produce first-quality timber, but some lengths at least will be utilizable and much more important is the fact that such trees do not interfere with neighbouring stems which will in all probability form the final crop.

The high level of quantitative damage produced by *E. buoliana* attack places this species in the category of one of the most damaging insect pests of young pine crops.

II. *E. turionana.*

(*a*) *Life-cycle.* Adult emergences extend from the middle of May until late June and, the maximum duration of adult life recorded being 23 days, the flight period of the species ranges between the limits of the middle of May and the middle of July.

E. turionana failed to produce fertile eggs in captivity and no precise data can, therefore, be given of the duration of the egg state or of the characteristics of early larval life. The earliest stage in the life-cycle recorded during field examinations was the second instar larva which in July was found boring within buds. Whether the first instar larva immediately after emergence from the egg bores into a bud as has been suggested by previous writers or whether, like that of *E. buoliana*, the larva spends a period in a different feeding-site has not been conclusively determined. Feeding on the bud tissues continues until the onset of hibernation in October, and by that time one, two, or more buds of the whorl, depending on size, have been excavated. In contrast to the larva of *E. buoliana*, that of *E. turionana* almost invariably attacks the central bud of the whorl before hibernation and, in fact, most frequently hibernates in the hollowed out central bud or in a small tunnel excavated in the pith of the shoot immediately below the central bud. Some of the larvae are full fed when they hibernate and in the following March pupate without further feeding. A proportion of the population, however, resume feeding in spring and continue until early May when pupation takes place. All individuals pupate before the buds flush and damage is never inflicted on the young shoots as occurs with *E. buoliana*. The pupal period varies between 3 and 9 weeks.

(*b*) *Effect of Attack on Host Plant.* The most common host tree species is *P. sylvestris*, and *P. contorta* var. *Murrayana* is also attacked but to a lesser extent. *P. laricio*, *P. pinaster*, and *P. ponderosa* Doug. examined near attacked plantations of *P. sylvestris* showed no indication of infestation.

The results of attack by *E. turionana* are in many ways similar to those by *E. buoliana*. Infestation of a bud whorl by a larva of *E. turionana* invariably produces a distortion of subsequent growth which is of greatest importance when a leading shoot bud whorl is affected. The degree of forking is subject to wide variation depending on the relative vigour of the lateral shoots produced but is frequently severe since often the central bud is killed without any of the laterals being injured. Infrequently the central bud is unaffected, lateral buds only being excavated, and in this condition damage is negligible. Very infrequently, and then usually only on whorls of much reduced vigour, all the buds of the whorl may be killed, in which case height growth is continued by a lateral branch from below

the point of injury, resulting in a serious deformation. 'Posthorns' are never produced by the activity of a larva of *E. turionana*.

The leading shoot of a single tree may be attacked by *E. turionana* in successive seasons, resulting in an increase in the net amount of damage and eventually producing a very badly formed tree.

(*c*) *Forest Status*. The data on the forest status of this species has been obtained by a detailed examination of a sample plot area and by inspections of numerous attacked pine crops in the north-east of Scotland.

The sample plot was a square one-half acre in extent and was situated at Inver, Aberdeenshire (O.S. 1-inch, sheet 44, ref. 222928), the south side of the plot being formed by the southern boundary of the main Creag-na-Spaine block. The plantation was 14 years of age when the data was collected in 1948 and was known to be infested by both *E. turionana* and *E. resinella*. Data on the infestations by both moth species was obtained by examining every bud whorl and every annual node on each of the 911 trees in the plot, thus recording data not only on current infestations but also on previous years' attacks. Such collection of data of previous infestations was possible because galls of *E. resinella* remain *in situ* for a number of years and because the site of a previous infestation by *E. turionana* can be detected not only by the distortion but also in many cases by the presence of the hollowed-out bud or buds.

The data collected for each tree were:—

1. The number of infestations, for each of which was recorded (*a*) moth species, (*b*) vertical height of site of infestation from ground level, (*c*) year of infestation, (*d*) quadrant of tree (north, south, east, or west) in which the infestation occurred, and (*e*) whether on lateral branch, main stem, or replacement leader, this last term being used to designate a shoot which had replaced the true leader after previous attack.
2. The height of the tree, a figure which was used as a measure of the vigour of the tree.
3. Any unusual features of attack or symptoms of other pathological agencies.

The data were subjected to statistical analysis and the following main conclusions reached for *E. turionana*:

(i) The distribution of infestations in the horizontal plane is random; infested trees do not tend to occur in groups.

(ii) Peak infestation occurs between the tree height of 3 to 4 feet; peak infestation on leading shoots occurs at approximately 3 feet. This indicates a preferred flight level on the part of the moths.

(iii) Occurrence of infestation does not significantly affect the height of the tree infested.

(iv) The mean height of the tree crop (assuming it to be or have been within the susceptible height range) does not significantly influence the total density of infestation.

(v) Infestations do not tend to occur on trees which have previously been attacked in preference to unattacked trees.

(vi) Infestations occur most frequently on the east and south sides of individual trees. This may indicate a preference to seek sheltered conditions for ovipositing on the sides of the tree away from the prevailing wind.

In addition to the Inver sample plot data, numbers of randomized strip samples were taken in attacked pine crops throughout the north-east of Scotland to assess the quantitative damage caused by this species. Serious deformations occurred usually on only from 15 to 25 per cent. of the total number of trees in the crops, the maximum figure recorded being 35 per cent. (Montreathmont Forest, Angus). The silvicultural effect of such a level of damage is not great since, the attacked trees being distributed at random throughout the crop, a sufficiency of unattacked trees or of trees showing good recovery from attack is left to constitute the main crop.

The general impression gained during the course of the investigation was that *E. turionana* is a species of much less virility than *E. buoliana* and it is certainly not so serious a forest pest as the latter species.

III. *E. resinella.*

(*a*) *Life-cycle.* Adult emergences extend from late May until early July and, the maximum period of adult life recorded being 27 days, the flight period of the species ranges from late May until late July.

The preoviposition period varies between 1 and 7 days, the eggs being deposited on current year's shoots. The average duration of the egg stage is 22 days. The newly emerged larva which measures 2 mm. in length bores through a needle sheath immediately below the bud whorl into the bases of the needles under cover of a small silken web. A few days later the larva excavates a groove on the surface of the shoot between the originally attacked needle cluster and the bud whorl and roofs it over with silk and resin. This is the first stage in the formation of the resin-gall, and whilst feeding continues during the summer it is gradually enlarged until at the time of hibernation it is slightly larger than a pea and is greyish-white in colour. Beneath the gall the larva has excavated a short tunnel in the pith and in this the larva hibernates. In the following March or April feeding recommences and the gall, during the second summer's feeding, is enlarged by the addition to it of fresh resin until in October, when hibernation again occurs, it is slightly over 1 inch in diameter. The second year's resin actually encloses most of the first year's gall so that the final structure is divided into two distinct chambers. The larva which hibernates in the second winter is full fed and pupates within the gall in March without any further feeding. The pupal period lasts from 8 to 12 weeks.

(*b*) *Effect of Attack on Host Plant.* The salient feature of the feeding of the *E. resinella* larva is that the larva does not bore into the buds but restricts its activity to the shoot below the buds. Any damage to subsequent growth is caused, therefore, by the disruption of the conducting tissues of the shoot on which the gall is formed and not by any direct injury to the buds or the shoots which they later produce. Thus the damage inflicted is inversely proportional to the size and

vigour of the shoot on which the gall is formed. Three main conditions are found:

(i) On small shoots of low vigour the buds above the gall fail to produce shoots and the gall terminates the shoot.

(ii) On a shoot of intermediate size and vigour the shoots produced by the buds above the gall are weakly and deflected to a lesser or greater extent from their normal line of growth.

(iii) On a large and vigorous shoot all shoots produced by the buds above the gall are normal.

(*c*) *Forest Status.* The main conclusions indicated by the analysis of the Inver sample plot data for *E. resinella* are: (i), (iii), (iv), (v), and (vi)—as for *E. turionana.*

(ii) Infestations by *E. resinella* tend less than those of *E. turionana* to be concentrated at a specific height on the host tree. In general, lateral shoot infestations are more frequent than leading shoot infestations. In particular under 6 feet lateral shoot infestations predominate, but at and above this height lateral and leading shoot attacks are more evenly distributed. This analysis shows that the flight level for *E. resinella* is a diffuse zone of from 2 to 7 feet.

The silvicultural effects of attack by *E. resinella* are insignificant since only the weakest shoots are terminated by gall formation and since attack is most frequent on lateral shoots. The Inver sample plot data showed that only 8 per cent. of attacks resulted in the death of the shoot and that all trees so affected were below average in vigour and in some cases showed other pathological symptoms. Expressed as a percentage of leading shoots killed to total number of trees examined, *E. resinella* attacks accounted for the death of the shoot in only 0·39 per cent. of cases. The only practical significance of *E. resinella* attack occurs when the gall is formed on the leading shoot. Typically, growth of the main stem continues normally, but at the point of attack a weakness is formed and for several years after attack the stem may be broken at this point by such agencies as wind or snow.

To sum up, *E. resinella* is a species of very minor forest importance.

IV. *E. purdeyi.*

(*a*) *Life-cycle.* Adult emergences extend from late July until the middle of August and, the maximum period of adult life recorded being 23 days, the flight period of the species ranges from late July until early September.

The preoviposition period is 2 days, the eggs being deposited on current year's needles and, less frequently, on shoots. The average duration of the egg stage is 20 days. The newly emerged larva, which measures 1·2 mm. in length, bores into a current year's needle, most frequently near the apex but occasionally near the midpoint. Until hibernation the larva mines within the needle consuming most of the contents of the portion on which it feeds. Hibernation occurs at the end of October within the excavated needle. In the following spring the larva again feeds on the needle contents and later, when the buds flush, migrates to the new shoots and feeds by boring through the needle sheaths into the needle bases.

The needles are severed and fall, leaving the sheaths empty. Each larva destroys several needle clusters. Feeding continues until late June or early July and pupation takes place amongst the remaining needles, the pupa being attached to them by a few strands of silk. The duration of the pupal period is from 3 to 5 weeks.

(*b*) *Effect of Attack on Host Plant. P. laricio* is the most usual host tree of *E. purdeyi*, although the moth also breeds on *P. leucodermis* Antoine, but to a lesser extent. *P. sylvestris*, even when present in mixture with attacked *P. laricio*, is immune from infestation.

The direct result of attack by the larvae of *E. purdeyi* is partial defoliation of the infested shoots. Prehibernatory feeding appears to have little effect on the tree, but the later more voracious activities of the larvae reduce the photosynthetic area to a marked extent. This reduction is reflected in a distinct decrease in length increment of the attacked current year's shoots and, less frequently, the shoot may be killed by the attack. The result of attack is most important on leading shoots, restricting height increment and producing a badly formed crown of bushy type.

(*c*) *Forest Status.* The following remarks on the forest status of the species must be regarded as tentative since only the single outbreak at Bawtry has been studied.

In this case the moth species attacked trees of from 10 to 15 years of age at a height of from 12 to 15 feet. The flight zone of the species is markedly influenced by wind and rain and in some seasons under bad climatic conditions the females were forced to oviposit on sheltered lateral branches rather than on the leading shoots which the moths prefer if the weather is suitable.

In the horizontal plane infestations tend to be heaviest on marginal trees exposed to sunlight whilst shaded trees are less susceptible to attack.

The silvicultural importance of the species rests solely on the reduction of height increment. In the Bawtry outbreak the incidence of serious crown distortions was low and has not proved severe enough to interfere with the quality of the stand as a whole. The rather specialized conditions—the presence of sunlight and of shelter or quiet weather—required by this species to enable it to attack leading shoots successfully tends to decrease its status as a pest, but it nevertheless remains a potential danger although its restricted distribution precludes it, as yet, from being classed as a serious insect enemy of Corsican pine woods in general.

CONTROL.

I. *E. buoliana.*

Experiments conducted in Aberdeen with this species demonstrate that *E. buoliana* is capable of breeding successfully under the climatic conditions of north Scotland. It is also a well-known fact that the larvae of the pine shoot moth can develop successfully in nursery pine stock. The combination of these two factors indicates that a danger exists of *E. buoliana* being imported to Scotland on such stock and of becoming established as a breeding species. Such an introduction would be most undesirable, particularly if the species were to become established in the important pine-growing areas of north-east Scotland, and it is strongly urged that all young pine trees which enter Scotland from England should be

subjected to thorough inspection to ensure that no hibernating larvae of the pine shoot moth are present.

The reason why *E. buoliana* has not naturally colonized the northern portions of the British Isles has not been elucidated. It can, however, be stated that the most northerly fully authenticated record of *E. buoliana* obtained by the present writer during the 4 years covered by the investigation was from Dumfriesshire.

The control of *E. buoliana* in areas where it is already present can best be attempted from the silvicultural aspect. Other methods, such as hand-picking infested buds or shoots, the application of insecticides at selected stages of the life-cycle, and the use of parasites to attain biological control, have been widely recommended in the past and, in practice, have met with varying measures of success. In large forest areas, however, such techniques are generally impracticable from the economic point of view and some of them yield only doubtfully efficient results. Silviculture can be utilized both in preventative and in curative roles. In the first, attention must be directed towards the production of crops which will show as far as is possible a resistance to heavy infestation. This can be attempted by good site selection to produce crops which will thrive well and show maximum vigour, especially during the early part of the rotation when the crop is passing through the susceptible stage; by substituting, in areas liable to heavy attack, resistant species, such as Corsican pine, in place of the susceptible Scots pine; by growing pine in mixture with other species; and by breaking up large pine blocks with belts of resistant species, either hardwood or coniferous [*vide* Friend and West (11)]. Silvicultural curative measures which should be put into effect after an attack depend primarily on the adoption of a well-designed thinning policy. The general principle should be that, in so far as is practicable without breaking canopy to too great an extent, distorted trees should be removed as early in the rotation as possible, leaving either unattacked trees or trees showing good recovery from attack to form the crop. In particular, badly forked stems which will develop into 'wolves' should be removed at the earliest opportunity. Their removal should take precedence over that of trees with 'posthorn' damage, which can safely be left as a constituent of the crop to maintain density of stocking and canopy cover until after the removal of the more seriously distorted trees. Observations in East Anglia reveal that if this thinning principle is put into effect, there is every possibility of obtaining a final crop of fair quality even from the most seriously attacked plantations.

II. *E. turionana.*

The general principles for the control of this species are very similar to those for the pine shoot moth. Silviculture, which can again be used both in a preventative and in a curative capacity, should be given preference over other methods of control. The recommendations for crop formation and for thinning after attack made for *E. buoliana* are equally applicable to *E. turionana.*

III. *E. resinella.*

The very low level of economic damage inflicted by this species makes the

formulation of control techniques unnecessary. It is, however, suggested that, in plantations where high populations of the moth have been present, trees which have been weakened by an attack on the main stem should be removed as early as possible if this can be done without detriment to the development of the crop as a whole.

IV. *E. purdeyi.*

This species is generally restricted to sheltered situations. Preventative measures should, therefore, be directed towards increasing the environmental resistance to the moth species by destroying oversheltered conditions within the plantation. The following recommendations, suggested by Forestry Commission officers at Bawtry, appear feasible:

(i) Brash early to increase the circulation of air within the plantation. Brashing is also useful in that, if infestation is already present, many larvae will be destroyed by the removal of living branches from ride-side trees.
(ii) Thin early, again to increase air circulation in the crop.
(iii) Avoid planting mixtures of Scots and Corsican pines in areas liable to attack by *E. purdeyi*. It has been observed at Bawtry that the initially faster growing Scots pine provide shelter for the moth to breed on the Corsican pine members of the crop.

Remedial treatment should be directed towards the removal of attacked trees in early thinnings. Evidence from Bawtry shows that, in pure Corsican pine plantations, all infested material can be safely removed in the first thinning. In mixed crops it is not always possible to remove all infested material during the first thinning operation, but it is anticipated that in the second thinning, which has not as yet been undertaken, all affected trees can be removed.

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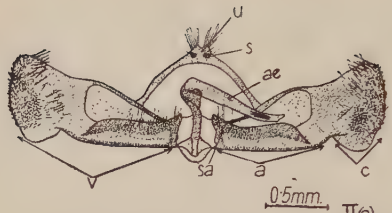

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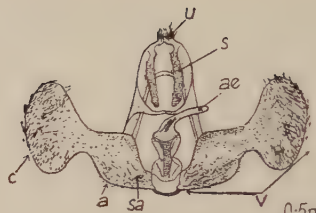

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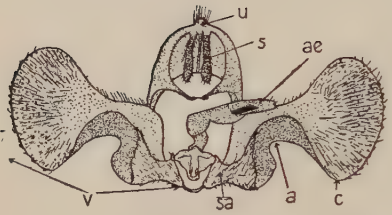

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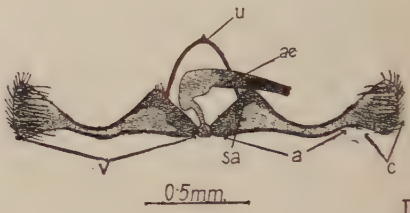

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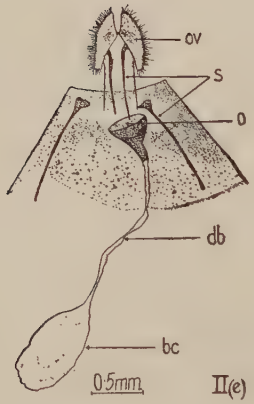

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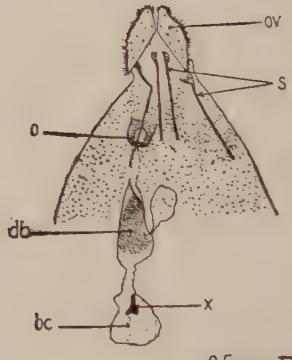

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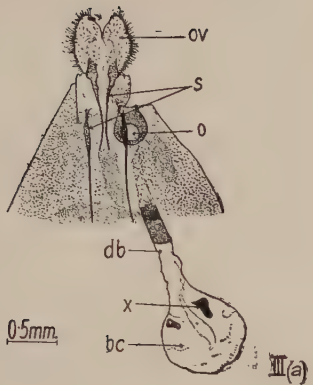

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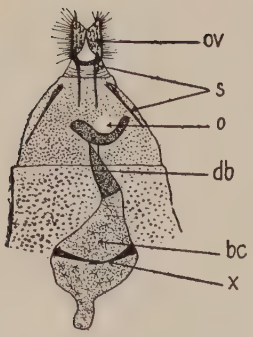

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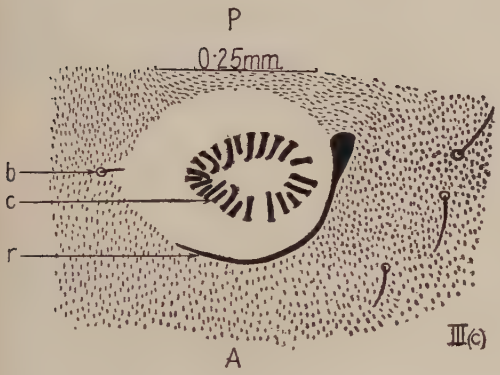

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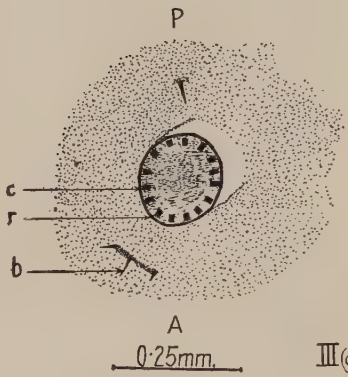

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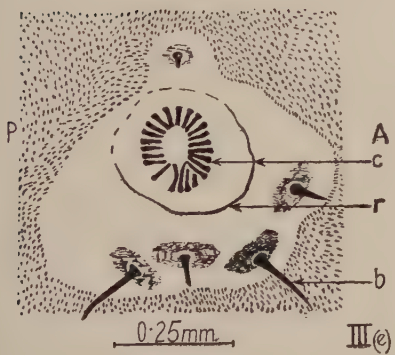

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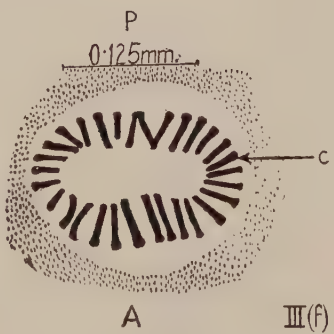

III(f)

DESCRIPTION OF PLATES AND LINE FIGURES

I(*a*) Adult of *E. buoliana*.
I(*b*) Adult of *E. turionana*.
I(*c*) Adult of *E. resinella*.
I(*d*) Male (left) and female (right) adults of *E. purdeyi* in act of copulation.
II(*a*) Male genitalia of *E. buoliana* (semi-schematic); *v*, valva; *a*, arm; *c*, cucullus; *sa*, sacullus; *u*, uncus; *s*, socius; *ae*, aedoeagus.
II(*b*) Male genitalia of *E. turionana* (semi-schematic); lettering as in II(*a*).
II(*c*) Male genitalia of *E. resinella* (semi-schematic); lettering as in II(*a*).
II(*d*) Male genitalia of *E. purdeyi* (semi-schematic); lettering as in II(*a*).
II(*e*) Female genitalia of *E. buoliana* (semi-schematic); *ov*, ovipositor; *s*, struts; *o*, ostium; *db*, ductus bursae; *bc*, bursa copulatrix.
II(*f*) Female genitalia of *E. turionana* (semi-schematic); *x*, signum; other lettering as in II(*e*).
III(*a*) Female genitalia of *E. resinella* (semi-schematic); lettering as in II(*f*).
III(*b*) Female genitalia of *E. purdeyi* (semi-schematic); lettering as in II(*f*).
III(*c*) Abdominal proleg of *E. buoliana* mature larva; A, anterior end; P, posterior end; *c*, crotchet; *b*, bristle; *r*, chitin ring.
III(*d*) Abdominal proleg of *E. turionana* mature larva; lettering as in III(*c*).
III(*e*) Abdominal proleg of *E. resinella* mature larva; lettering as in III(*c*).
III(*f*) Abdominal proleg of *E. purdeyi* mature larva; lettering as in III(*c*).
IV(*a*) Group of five *E. buoliana* eggs deposited on current year's shoot of Scots pine near base of a pair of needles, which have been removed for clarity.
IV(*b*) Forking of main stem of young Scots pine tree caused by *E. turionana* attack. A similar type of distortion can be inflicted by *E. buoliana*.
IV(*c*) Mature second-year gall of *E. resinella* formed on Scots pine shoot. Note empty pupal case projecting through the wall of the gall.
IV(*d*) Second instar larva of *E. purdeyi* mining in needle of Corsican pine. Needle sectioned to reveal larva.

Note. Plate III comprises I(*a*) (*b*) (*c*) (*d*). Plate IV comprises IV(*a*) (*b*) (*c*) (*d*). II(*a*) (*b*) (*c*) (*d*) (*e*) (*f*) and III(*a*) (*b*) (*c*) (*d*) (*e*) (*f*) are line figures.

PLATE III

PLATE IV

RESTOCKING DERELICT WOODLANDS: A SCOTTISH EXAMPLE

By M. J. PENISTAN

(*Forestry Commission*)

SUMMARY.

The prescriptions drawn up for the restocking of an area of lowland scrub forest in Ayrshire by saving the useful regrowth and by partial planting are given and the work actually carried out is described. Costs are compared with adjacent clear felling and replanting, and the possibility of the extension of the method to other similar areas is considered.

INTRODUCTION.

THE treatment of derelict woodlands was demonstrated during part of the Society's excursion to Lincoln in 1948 and was discussed at Hereford in 1949. The problem is chiefly English (2) and associated with *Rubus* type vegetation.

Conditions do, however, occur in Scotland where *Rubus* at low altitude is locally luxuriant following on clear felling, and in these localities scrub derelict areas do develop. The present notes indicate the problem and the methods employed at one small area in Ayrshire in woodland belonging to the West of Scotland Agricultural College on the banks of the River Ayr. This area lies alongside demonstration fields and can be pointed out to visitors. This is important as most of the scrub areas are now found on single farm properties following the breaking up of larger estates. At present they tend to be grazed by heifers and bullocks, which results in an even more intractable scrub developing in which all the useful saplings have been damaged by cattle.

SITE.

The area is part of Craighall Wood (national grid reference 26/398233) on the left bank of the River Ayr, 120 feet above sea-level. The aspect is east, and the area is sheltered from the prevailing westerly winds. The site consists of a flat haugh by the river carrying heavy bracken (*Pteris aquilina*) and in open spaces dense willow-herb (*Epilobium angustifolium*). The soil is alluvial drift, a rich sandy loam. Above this there is a steep bank of rich clay loam with a dense undergrowth of hazel (*Corylus avellana*), among which regrowth of oak (*Quercus robur*), ash (*Fraxinus excelsior*), elm (*Ulmus montana*), sycamore (*Acer pseudoplatanus*), cherry (*Prunus avium*), birch (*Betula pubescens*), and beech (*Fagus sylvatica*) occurs, laced through with vines of *Rubus*. The prevernal aspect is *Scylla* dominated.

The degree of drainage varies; where the soil is moist the *Rubus* is heavy and rampant in the clearings, where it is drier it gives place to bracken. The underlying rock is Coal Measures, though the drift is affected by a nearby intrusion of basalt.

There are few rabbits, due to the activities of poachers, but there is a fox earth within the area.

CROP.

The previous crop was of mixed hardwoods including some fine larch (*Larix decidua*) and was cut down in 1927. The dense thicket described above has since developed and from the outside the aspect was not encouraging when replanting was being considered. Externally the area appeared to be chiefly hazel intermixed with *Rubus*, with a few natural seedlings showing above. On penetration good crops of ash seedlings in the canopy with occasional cherry and birch of poorer type were found. The birch was dominant on the tops of slopes. On the haugh were small groups of alder (*Alnus glutinosa*) and poplar (*Populus serotina?*). Throughout the thicket coppice growths of sycamore, oak, elm, and alder were scattered.

TREATMENT.

This scrub derelict area was extensive, occupying all the steeper banks of the river, and had been cleared annually prior to the planting of 5-acre blocks of conifers. In 1948 the woodman, who had assisted in the cutting of the previous crop, left a few scattered maiden ash stems in the planting area, and pointed out the presence of a great many other saplings in the areas not yet cleared. The stems were of the highest quality, giving very rapid growth and showing white, clean, uncankered bark. Inspection of the remaining 17 acres showed that a good deal of this growth could be utilized without planting and the following prescription was then made:

(*a*) Leave all maiden stems of cherry, elm, oak, and sycamore, where these are straight and clean. Cut out all coppice shoots and bad stems of these species.
(*b*) Leave all ash thickets, cutting out only the forked stems and those saplings that are too drawn to stand. All stems should be cut cleanly at ground level.
(*c*) Cut out all scrub and burn it away from the saplings.
(*d*) Thin out the birch areas to 10-foot intervals.
(*e*) All poplars showing any signs of canker should be cut, but individual trees apparently free of disease should be retained. A screen of alder should be retained by the river.
(*f*) Plant Norway spruce (*Picea abies*) in the gaps formed by the removal of bad stems from the thickets and through the birch with a protective belt of Sitka spruce (*Picea sitchensis*) and beech on the windward upper edge of the area. Plant the remaining ground with hardwoods, chiefly oak and ash, with European larch and Norway spruce as nurses. The wide spaces in the level haugh to be planted with poplar cuttings at 15-foot intervals.

In practice these prescriptions were accurately followed by the woodman with the exception of the planting of nurses for the hardwoods. The mixture he used was alternate plantings of oak and beech with Sitka spruce, which was the only conifer obtainable.

The completion of cleaning and planting on the above prescriptions showed a find stand of sapling ash, varying in size from 2-foot seedlings to 15-foot young

poles all of first quality and occupying some 2 acres, which required no restocking. There is a local inter-mixture of cherry, elm, oak, and beech saplings. The more open areas now contained free standing saplings of ash and cherry and had been interplanted. The stools of the rougher ash in this zone were shooting vigorously and making up to 5 feet in their first year but averaging 2 feet.

The number of plants required was reduced by some 3 acres, and up to 15 years' growth on the largest ash saplings has been preserved to grow on to high-class timber. As the more drawn poles steady they will need a further cleaning to bring the spacing from 3 feet average to 6 feet average, the finest sticks being allowed to remain and badly forked ones being cut out.

It was of considerable advantage to have the work carried out by a woodman who knew the excellence of the previous crop and who was quite agreeable that this was a site for growing hardwoods in preference to fast-growing conifers, and who had previously been upset when instructed to clear the excellent thicket regrowths of ash. The cutting back of the ash was well done and shoots were singled in the spring. Growth has been good, but from stools over 2 inches diameter the form was poor and unsuitable. Future cutting back of these larger stems will be accompanied by earthing over of stools.

COSTS.

Costs for the 1948–9 operations covering 10 acres at Craighall Wood were as follows:

	Total cost			*Per acre*		
	£	*s.*	*d.*	£	*s.*	*d.*
Clearing scrub	123	15	0	12	7	6
Cleaning ditches	11	0	7	1	2	0
Planting	40	3	4	4	0	4
Gassing rabbits	3	15	0	0	7	6
Weeding	22	5	0	2	4	6
Hauling wood to mill	175	7	3	17	10	8
Cost of plants	107	9	6	10	14	11
	£483	15	8	£48	7	5

Against this total for expenditure there is an income for wood sold as firewood and as pitwood, &c., which is estimated at a gross value of £600 less cost of sawing and delivery at £300, or a net income of approximately £300.

The net cost to the owner for restocking worked out at:

			Per acre		
	£	*s.*	*d.*	£	*s.*	*d.*
Total expenditure	483	0	0	48	6	0
Less net income	300	0	0	30	0	0
	183	0	0	18	6	0
Less grant payable	99	0	0	9	18	0
Net cost	£84	0	0	£8	8	0

It must be stressed, however, that all fencing costs were a charge borne entirely by the farm.

STRAIGHT PLANTING.

Adjoining this area is a wood of 15 acres under different ownership, where, during the same season, the planting of 9 acres cleared of scrub in 1947, but now carrying a heavy growth of *Rubus*, willow (*Salix caprea*), grasses dominated by *Aira caespitosa*, and bracken, was carried out. Two lines of oak and beech alternating with two lines of Norway spruce at 5 feet spacing were planted, the good growths of ash being retained. The expense of clearing the area prior to planting was offset by sales of firewood.

In this case the costs excluding fencing in 1948–9 were:

	£ s. d.	*Total cost* £ s. d.	*Per acre* £ s. d.
Preliminary clearing		7 0 0	0 15 6
Plants 5,000 oak	50 0 0		
7,500 beech	52 10 0		
6,000 Norway spruce	36 0 0		
		138 10 0	15 7 9
Planting-labour		54 11 0	6 1 3
Weeding throughout summer		48 13 7	5 8 2
		248 14 7	27 12 8
Less Grant		90 0 0	10 0 0
		£158 14 7	£17 12 8

It must be pointed out that a very considerable expense—that of fencing—has been left out. The reason for this is that in agricultural Ayrshire the number of rabbits is relatively small as they are heavily poached by miners, and rabbit fencing is not essential. Stock fencing is necessary for the agricultural management of the adjoining land, and all fencing maintenance is normally charged to the farm account as an outgoing.

The produce from cleanings which might in other areas be uneconomic was at Auchencruive used for temporary and electric fences, and the balance creosoted for permanent use.

GENERAL APPLICATION.

The net cost of converting these Ayrshire lowland scrub areas appears to be in the neighbourhood of £10 per acre including grant. These sites are the only really high-class hardwood producing areas in the county and could relatively easily be brought back into production. The use of Norway spruce as nurse trees will make the operation profitable within a few years, the trees being cut out for Christmas trees where regrowth of ash allows and as the hardwoods develop, and should appeal to farmers. The demonstration of this area and of the costs of conversion

to a profitable forest should encourage the better use of these rich drift-covered banks unsuitable for agriculture within the Coal Measure areas of Ayrshire.

(*Received August 1950*)

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FORESTRY IN NORTHERN IRELAND

By W. N. GIBSON

(*Forestry Commission*)

SUMMARY.

The progress made in forestry under the Ministry of Agriculture since 1921 is discussed, and conditions compared with other parts of the United Kingdom. Climatic and soil conditions are considered and notes given on the principal species used and their suitability for the sites available. In addition drainage, planting methods, management, and utilization of small produce are all lightly touched on and figures given for the areas acquired and the acreages planted to date.

IT may be of interest to foresters in Britain to know something of present-day forestry in Northern Ireland and the problems which are being dealt with there.

This small country has established a reputation for its up-to-date and intensive methods of agriculture, but it is a surprising fact that it is at the same time the most poorly wooded part of the British Isles and indeed, apart from Iceland, it has a lower percentage of its land area under woodland than any other country in Europe. This has not always been the case as there are records of the great forests which covered a large part of the country in ancient times. With the growth of the population and increasing demands for land for cultivation and grazing the forests were gradually cut down or ruthlessly destroyed, until by the middle of the last century it was only on the larger estates that any extent of woodland was to be found. Only in a few exceptional cases were any serious attempts in forestry made by the private estates and indiscriminate felling has been the rule for many years.

The various Irish Land Acts led to the breaking up of the large estates and few extensive private properties now remain. The two World Wars have completed the devastation of the country's woodlands so that there are now practically no large stands of mature or middle-aged timber left. There are, however, still some scattered remnants of fine old hardwoods, chiefly oak, beech, ash, and elm, to give encouragement to the forester, and these with a few isolated groups of old Scots pine and the massive roots in many of the bogs bear witness that considerable areas of fine timber once existed and could again be grown in the country.

After the First World War the realization of the denuded state of the woodlands and the tremendous importance of timber during the war to the British Isles led to the Government's proposals for afforestation and the formation of the Forestry Commission. These proposals applied to Ireland as well as Britain and a start had actually been made before the Anglo-Irish Treaty of 1921 was ratified and forestry responsibilities for Northern and Southern Ireland were taken over by their respective Departments of Agriculture.

In the preparation of a programme of afforestation for Northern Ireland it has

been necessary to recognize that certain essential differences exist between conditions there and in other parts of the United Kingdom. Whereas in Great Britain forest policy depends on the close co-ordination of private and State forestry, in which the private estates have an important part to play, in Northern Ireland, owing to the small size of most properties, the limited area available for planting, and lack of staff and experience, the responsibility for carrying out of the programme of afforestation lies mainly with the Government.

Since the Ministry of Agriculture for Northern Ireland commenced its forestry operations the acquisition of land for forestry has proceeded steadily though somewhat slowly. This is mainly due to the small size and high price of individual properties offered for sale, and the difficulty of obtaining sufficient land to make an economic forest unit in districts which are remote from any existing forest. Nevertheless, a total of some 53,000 acres has to date been purchased or leased, and of this area 29,600 acres have now been planted. The annual planting programme has gradually risen to 2,000 acres and this figure will probably be still further increased as plants and trained staff become available.

The plantable land is extremely varied, ranging from the good heavy loams and clays of the old demesne or park-lands, once part of large estates, to the deep peat of the higher hill-sides or bogs at lower elevations. The climate of Northern Ireland is exceptionally well suited to tree growth, being mild and damp. Severe winter frosts and snow are rare, though damage is occasionally caused by late frosts.

To meet the wide range of soil types a large variety of species has been planted, including all the common hardwoods and conifers as well as a considerable number of exotics. Some interesting facts regarding mixtures and choice of site are now apparent from the earlier plantations and the following notes on some of the species may prove useful to foresters.

HARDWOODS.

These have been planted on the better sites, either in pure crops or in mixture with a conifer nurse. The usual practice has been to plant the hardwoods in groups of five spaced at either 15 or 20 feet apart with conifers between the groups.

Oak and elm are generally planted with a Norway spruce nurse and ash with European larch. Some very promising plantations have resulted from this method, and at 15 years the removal of the nurse trees has been begun to favour the hardwood crop.

In one case an excellent crop of ash has been obtained by planting two rows of ash alternately with a single row of European larch. The larch were completely removed by the 16th year, leaving a pure crop of ash.

On most old hardwood sites a considerable amount of natural regeneration of ash, sycamore, and oak usually occurs, and in thinning of young conifer plantations the natural hardwoods have been favoured, with the result that some fine mixed stands have been produced.

CONIFERS.

Scots pine. Except on low ground and sheltered sites this species suffers severely from browning and loss of needles. A notable exception is at Newcastle Forest on the eastern slopes of the Mourne Mountains where, although facing the sea, there are some excellent plantations showing little or no sign of browning. The soil is a shallow sandy gravel derived from granite and it seems possible that edaphic as well as climatic factors may have some bearing on the cause of needle cast in Scots pine, which is so prevalent in most western coastal districts of the British Isles. Some account must also be taken of the fact that practically all the Scots pine which has been planted in Northern Ireland is of eastern Scottish origin and better results might have been obtained if seed could have been procured from native pine or from the west of Scotland where races of pine have developed which are resistant to the blasting effects of the western sea-breezes.

Pinus contorta. This species has been fairly extensively planted on high exposed sites and on poor peat areas where it is generally used in mixture with Sitka spruce. Both the true *murrayana*, or inland, as well as the coastal variety have been used, but it has now been recognized that the *murrayana* variety has little advantage over Scots pine on exposed sites where it appears to suffer equally severely from needle cast.

The coastal, or shore pine, on the other hand, although it may not produce high-quality timber, has made exceptionally good growth even on the most exposed sites. The denser foliage and more vigorous habit of growth of this variety gives quicker suppression of the vegetation and make it of considerable value for planting either in mixtures or as a pioneer crop on a wide range of poor soils.

European larch grows extremely well and has produced some excellent plantations both pure and in mixtures, especially with hardwoods.

With the exception of one small plantation, die-back of European larch, which has caused such widespread damage to young plantations in southern and eastern Scotland, is unknown in Northern Ireland. In the case of the single exception the larch is of Alpine origin. At 16 years the trees have an average height of 20 feet and up to 50 per cent. of the crop is now either dead or dying. The habit of growth is coarse with short, thick side branches. Adjoining this plantation, on an identical site, is one planted in the same year with plants from seed of Scottish origin, and the difference in the two races is very clearly demonstrated. In this case the trees average 30 feet in height and they are completely free from die-back and are vigorous and healthy with clean straight stems and finely branched. Some of the earlier plantations of European larch in Northern Ireland were affected by die-back, but these plantations, which were all known to be of continental origin, were with the single exception described above cut out during the war and have now been replanted.

The susceptibility of continental strains of larch to die-back was fully recognized by 1926, and since then only plants produced from Scottish seed have been used, with the result that this trouble has been completely eradicated.

This evidence supports the views held by many foresters that the die-back trouble which has been experienced in the cultivation of European larch in recent years is undoubtedly a question of seed provenance.

Sitka spruce is the predominant species in the young plantations now being established, and it is ideally suited to the climate and soils over the greater part of Northern Ireland. On the heavy clay loams of Tyrone and Fermanagh some exceptionally fine young stands have been produced and the rate of growth and volume of timber per acre probably compare favourably with any in the British Isles.

Thuya plicata has not been extensively planted, but there are some very good plantations of this species and it could probably be more extensively used for certain difficult sites. On shallow *molinia* peat over a hard stony subsoil it has shown itself to be superior to Sitka spruce, making rapid growth while the spruce remains in partial check.

Abies nobilis has in several places been planted in mixture with Scots pine on dry stony soils on exposed sites with *calluna*/grass vegetation.

At Tardree Forest, County Antrim, there is an excellent example of this mixture planted in 1932 at 900 feet on a fully exposed site. The mixture was 25 per cent. *Abies nobilis* and 75 per cent. Scots pine, and the pine is now only 3–6 feet in height and severely blasted while the *nobilis* varies from 10–20 feet in height and is making rapid growth and showing no signs of blast.

This species appears to have considerable possibilities for sites of this type.

Two other exotic species which have produced good stands of young timber are *Cupressus macrocarpa* and *Sequoia sempervirens*.

PREPARATION OF GROUND FOR PLANTING.

Draining and turfing has been the normal practice on all wet or peaty soils and in recent years the introduction of tractors and special ploughs has led to an improvement in technique and a great reduction in the cost of the work.

On most of the hills deep peat occurs on the intermediate and higher slopes and often covers extensive areas. Much of this land was formerly considered to be unplantable, but with modern equipment and as a result of experience timber crops can now be established with reasonable hopes of success on all but the most exposed and unfavourable sites. This is a development of the greatest importance in a small country like Northern Ireland where the land available for planting is limited.

The transition from the lower hill slopes with grass/*juncus* and mineral soils with peaty flushes to the deep *eriophorum* bog above is usually sudden and the peat may be up to 10 feet in depth. The method of dealing with these deep hill bogs is to construct a cut-off drain along the upper limit of the plantable land, this drain being cut through the peat to the subsoil. The area is then drained or ploughed by caterpillar tractor and a deep hill draining plough.

Though the surface condition of these bogs is generally very poor with an unfavourable *eriophorum*/*sphagnum* association, the drainage leads to an immediate

improvement and within a year this can be seen by the strong growth of *Aira flexuosa* which usually occurs.

The improvement resulting from intensive drainage of these hill peat areas is much more rapid than is usually the case with similar types in Scotland, where the depth of the peat is much less, and this may be due to the milder climate of Ireland and the non-fibrous type of peat which responds more readily to drainage and shrinks and weathers fairly rapidly.

In many districts large areas of bog have been cut over for fuel and these present no difficulty in drainage and planting. On many of the forests the letting of turf banks is an important source of revenue while at the same time it improves the value of land for planting.

Ploughing has also been found to be an advantage even on the better soils as it reduces weeding costs on rank grassy areas. On this land a shallow furrow is turned out by a light plough drawn by an ordinary agricultural tractor with metal wheels.

Hardwoods as well as conifers are being successfully planted on the ploughed furrows and a considerable saving in weeding costs has resulted.

PLANTING METHODS.

For planting on ploughed or turfed areas the 4-inch semicircular planting spade is in general use and has given very satisfactory results. On poor peat ground mineral phosphate or basic slag is applied in the hole at the time of planting at the rate of 2 oz. to the plant. For direct planting on all but hard stony ground the 6-inch semicircular spade is used and has proved itself a useful tool.

Successful plantations have been established using 2-year seedlings of both Norway and Sitka spruce on turfs, but transplants are normally used. Good results have also been obtained with 1-year oak seedlings.

NURSERIES AND PLANT SUPPLY.

Plants are supplied from the Ministry of Agriculture's forest nurseries and the areas have recently been increased to keep pace with the larger post-war planting programmes. The great variety of both hardwood and conifer species planted means that large stocks of plants must be carried. In addition, as there are no private forest nurserymen in Northern Ireland, the Ministry of Agriculture has undertaken to supply as far as possible the plants required for private planting.

MANAGEMENT OF PLANTATIONS.

Large areas of the older plantations have now reached the thinning and pruning or brashing stage, involving the need for more skilled and intensive supervision and the employment of additional labour.

Complete brashing has been found more satisfactory than any of the more half-hearted methods. The cost of this operation has been kept within reasonable limits and it has been found that it is an advantage to delay brashing until just before the first thinning, by which time, especially in the case of Sitka spruce, the fine twigs which are often very numerous between the main whorls of

branches have become brittle and can be easily brushed off without sawing, thus considerably reducing the cost of the work.

Thinning of the older plantations is now in full swing and various thinning and extraction systems are used. On one of the largest forests with a big thinning programme and where there was a labour shortage, different methods of line thinning in Sitka spruce have been tried out. The removal of every third row of trees was first tried, but it was later decided that removing every fourth row was a more satisfactory method. No trees are removed from the intermediate rows, but it is intended to carry out a second thinning in 2/3 years.

This method has been very satisfactory in thinning good even-grown stands which have few bad tops and rough trees, and it has the advantage of greatly reducing thinning and extraction costs and the cleared rows provide permanent drag lanes for subsequent thinnings. It is of little value unless the rows follow the best line for extraction and it is not recommended for uneven crops or where there is a large number of bad tops or rough trees.

The interval between thinnings, especially in the faster growing stands of Larch and Sitka spruce, is usually about 3 years and there has been very little serious damage by wind blow.

PRODUCE.

A considerable and rapidly growing volume of timber is now being produced from the plantations.

Second and subsequent thinnings from Sitka spruce provide a useful quantity of milling timber and there is a good demand by the local trade for timber of 5 inches diameter and up which is suitable for sawing and manufacture into egg cases and light boarding. Material under 5 inches top diameter is mainly converted to pitwood and a considerable quantity is shipped each year to the South Wales coalfields. Light tops of all species are cut into stakes and fencing material for which there is always a ready market.

FOREST ROADS.

Road-construction work was begun on many of the forests within the last few years and was regarded partly as a relief scheme to provide employment in certain areas. The work was supervised by the foresters and forest officers, and it is a very creditable performance that it has been possible to provide many miles of useful motor roads through the forests at a reasonable cost without any skilled engineering assistance or elaborate equipment.

PRIVATE PLANTING AND ADVISORY WORK.

Apart from the work of establishing and maintaining large areas of new plantations, a considerable amount of advisory work is done and every encouragement is given to private owners and farmers to undertake planting schemes. A planting grant of £10 per acre is paid for approved areas of 4 acres and over, and plants are supplied from the Ministry of Agriculture's forest nurseries at special rates to anyone requiring 1,000 plants or more.

This scheme has proved to be exceedingly popular and many thousands of plants are supplied each season. A large proportion of the plants is used for planting up small corners of waste ground or establishing shelter belts on farms, and although they cannot be regarded as providing any great potential source of timber, the general effect will be of benefit to the country as a whole.

The Ministry of Agriculture's programme of afforestation is already making its mark on the country-side and on many bare hill-sides the young plantations now provide a mellowing and pleasing effect. Valuable timber is being produced from land which was mainly of little use to agriculture and useful employment is being provided in many districts where it was badly needed.

(*Received June 1950*)

A FALLACY IN THE THEORY OF GROWING STOCK

By R. BOURNE

APPENDIX

Enumeration Statements for Parmoor Beechwoods

(Volumes in hoppus cubic feet under bark)

[*See footnote on page 15, Forestry, Volume XXIV, No. 1*]

1. *Moor End Wood*: 24·90 acres.

D.B.H. in.	*1924*		*1931*		*1945*			
	Number	*Volume*	*Number*	*Volume*	*Number*	*Volume*	*Number*	*Volume*
6	228	342	58	85	85	170		
7	164	426	67	173	95	295		
8	282	1,126	62	249	103	453		
9	234	1,402	89	534	101	606		
10	427	3,113	169	1,232	117	936		
11	427	4,738	209	2,317	117	1,345		
12	339	4,816	227	3,223	159	2,385		
13	269	4,680	258	4,488	187	3,366		
14	187	3,859	293	6,048	209	4,493		
15	117	2,803	285	6,838	259	6,477		
16	64	1,774	227	6,261	202	5,056		
17	35	1,105	129	4,039	165	5,197		
18	17	619	124	4,420	128	4,544		
19	6	232	44	1,756	95	3,747		
20	6	254	31	1,352	88	3,828		
21	..	..	9	427	53	2,544		
22	..	..	9	471	36	1,908		
23	..	..	4	258	27	1,566		
24	..	..	..	..	16	1,008		
25	..	..	..	..	9	612		
26	..	..	..	..	5	360		
27	..	..	..	..	2	152		
28	..	..	..	..	..	..		
29	..	..	..	..	1	84		
30 and over	..	..	..	..	2	200		
Period	..	..	..	7 years	..	14 years		21 years
Closing growing stock . .	2,802	31,289	2,294	44,171	2,261	51,332	2,261	51,332
Yield .	..	..	466	7,886	292	9,937	758	17,823
			2,760	52,057	2,553	61,269	3,019	69,155
Less initial stock . . .			..	31,289	2,294	44,171	..	31,289
Increment				20,768	259	17,098	..	37,866
Periodic mean annual increment				2,967	..	1,221	..	1,803
Do. per cent. . . .				9·5	..	2·76	..	5·7
Do. per acre . . .				115	..	49	..	72

APPENDIX (*cont.*)

2. *Coachway*: 17·6 acres.

D.B.H. in.	*1924*		*1931*		*1945*			
	Number	*Volume*	*Number*	*Volume*	*Number*	*Volume*	*Number*	*Volume*
6	152	228	112	163	132	264		
7	229	598	119	308	82	256		
8	187	752	63	251	72	319		
9	332	1,994	176	1,055	79	474		
10	539	3,931	264	1,922	104	832		
11	350	3,882	163	1,810	153	1,754		
12	386	5,481	258	3,650	208	3,120		
13	332	5,782	308	5,358	197	3,546		
14	225	4,629	207	4,272	211	4,536		
15	144	3,452	176	4,221	182	4,550		
16	89	2,479	182	5,025	140	3,920		
17	54	1,686	75	2,350	90	2,830		
18	36	1,275	38	1,332	85	3,017		
19	..	..	25	987	38	1,496		
20	9	386	19	817	30	1,300		
21	..	..	..	..	25	1,200		
22	..	..	..	..	10	530		
23	..	..	..	..	5	290		
24	..	..	..	..	3	189		
25	..	..	..	..	2	136		
Period	..	..	..	7 years	..	14 years	..	21 years
Closing growing stock .	3,064	36,555	2,186	33,521	1,848	34,559	1,848	34,559
Yield .	..	..	439	3,638	708	11,019	1,147	14,657
			2,625	37,159	2,556	45,578	2,995	49,216
Less initial growing stock .			..	36,555	2,186	33,521	3,064	36,555
Increment			..	604	370	12,057	..	12,661
Periodic mean annual increment			..	86	..	861	..	603
Do. per cent. . . .			..	1·7	..	2·6	..	1·7
Do. per acre . . .			..	4	..	42	..	34

APPENDIX (*concld.*)

3. *Bottom Wood* (*Moor*): 30·2 acres.

D.B.H. in.	1924		1931		1945			
	Number	*Volume*	*Number*	*Volume*	*Number*	*Volume*	*Number*	*Volume*
6	392	588	278	409	268	401		
7	331	862	343	894	250	646		
8	446	1,782	266	1,066	270	1,080		
9	434	2,605	332	1,990	254	1,524		
10	471	3,436	350	2,546	245	1,790		
11	580	6,438	385	4,270	244	2,705		
12	435	6,162	468	6,641	275	3,901		
13	464	8,079	361	6,287	230	4,004		
14	352	7,248	403	8,295	242	4,988		
15	277	6,658	260	6,259	211	5,064		
16	144	3,969	154	4,251	215	5,928		
17	158	4,916	154	4,821	144	4,511		
18	90	3,208	53	1,889	98	3,479		
19	10	406	47	1,865	65	2,562		
20	18	784	36	1,540	46	1,996		
21	..	..	6	284	33	1,584		
22	6	320	6	314	15	795		
23	..	..	18	1,030	12	696		
24	..	..	..	..	3	189		
25	..	..	..	..	7	476		
26	..	..	..	..	2	144		
Period	..	..	..	7 years	..	14 years	..	21 years
Closing growing stock	4,608	57,461	3,920	54,651	3,129	48,463	3,129	48,463
Yield	..	..	487	8,199	1,134	28,014	1,621	36,213
			4,407	62,850	4,260	76,477	4,750	84,676
Less initial growing stock			4,608	57,461	3,920	54,651	4,608	57,461
Increment			..	5,389	343	21,826	142	27,215
Periodic mean annual increment			..	770	..	1,559	..	1,296
Do. per cent.			..	1·3	..	2·8	..	2·25
Do. per acre			..	25	..	51	..	43

SOCIETY'S AND OTHER NEWS

HONOURS

THE names of three Fellows of the Society appear in the Birthday Honours conferred by His Majesty the King in June 1951. Mr. H. R. Blanford, O.B.E., Editor-Secretary of the Empire Forestry Association, is promoted C.B.E. Mr. Blanford's work has long been known and admired all over the world. His genius has found expression in the last twelve years in the excellence of the *Empire Forestry Review*, which, published as a quarterly since 1949, has under his skilful editorship maintained and increased its importance in forest literature to its present very high position. The *Empire Forestry Review* is now indispensable reading for all interested in forestry everywhere. Mr. O. J. Sangar, M.C., Director of Forestry for England, Forestry Commission, is made C.B.E. Mr. Sangar was President of the Society last year, and an important contribution to present-day forestry in Great Britain from his pen appeared in the first number of this volume of *Forestry*. For services to discharged airmen of the Royal Air Force, which, as is well known, included several valuable practical courses in forestry at Huntley Manor, Mr. C. P. Ackers, J.P., is made O.B.E. These courses enabled many keen young men to settle down to forest work, where they are much needed to help put right the devastated areas.

Two others in the same list are Dr. F. Y. Henderson, Director, Forest Products Research, who is made C.B.E., and Mr. Matthew Feaks, Woods Manager, Moray Estates Development Company Limited, who is made M.B.E. The Society is looking forward to visiting the Forest Products Research Laboratory at Princes Risborough in September this year. Members who visited Darnaway in 1947 had the privilege of meeting Mr. Feaks and of being shown round by him. They will long remember the remarkable plantation work carried out there under his guidance.

REVIEWS

Thirtieth Annual Report of the Forestry Commissioners for the year ending September 30, 1949. London: His Majesty's Stationery Office, 1950. 4*s*.

Review by H. G. Champion

THIS report contains much more information than its title suggests as it includes a detailed review of the work accomplished by the Forestry Commission over the first 30 years of its existence, viz. 1920 to 1949 inclusive. This review is of particular interest in that the earlier practice of giving a quinquennial review has been in abeyance since 1934. The remarkable fact may also be noted that the signatory to the report, Lord Robinson, has been one of the Commissioners for the whole 30 years and their Chairman since 1932. Although the period considered only takes us up to a point where post-war adjustments and developments were still in active progress, the time seems appropriate for an examination of what has been accomplished, what more was hoped for, and what are now the immediate problems.

The Commission can, indeed, point to very solid accomplishment despite the great general slump of the thirties and all the consequences direct and indirect of the Second World War which brought with it even greater demands on home timber supplies and greater absorption of the national effort than the first. A million acres of plantable land have been acquired for forestry without resort to compulsory acquisition, and about half a million acres have actually been afforested (without counting in 182,000 acres planted by private owners with the help of monetary grants). A new forest nearly 80,000 acres in extent has been created on the Border, and no less than six forests, each over 10,000 acres, in Wales: even in eastern England we now have an artificial forest some 40,000 acres in extent round Thetford. During the war the national forests contributed 51 million cubic feet—a small proportion of our needs, perhaps, but an amount by no means insignificant. These forests now provide regular employment for some 12,000 workers, apart from the Commission's own staff. We now have reasonably reliable information of the area, nature, and stocking of the forests of the country, both publicly and privately owned, confirming that our resources amount to about 3½ million acres, or 6·5 per cent. of the land surface, carrying about 2,660 million hoppus feet.

We have schools to train staff and workers well distributed over the country, nurseries to provide the planting stock, a research station to take up the silvicultural problems that call for study, and most of the other facilities required to implement our national programme. Forestry is now a well-established activity in the country, and we have launched a further programme with so close a resemblance to the original one that it may be taken to indicate that the latter was on lines that are still acceptable.

In the light of the task set, there is no doubt that the chief item on which the record is much less satisfactory, and has consequently been very generally criticized, is the improvement in the condition and current increment of the privately owned woods. The need for effective measures to this end was clearly recognized in the Acland Report on which the Commission's 1919 programme was based and various lines of action were indicated. The planting subsidy was drawn to some extent, but it is doubtful whether the area replanted would have been very different without a subsidy. The woods were largely of hardwoods and mostly very different from the large Crown Forests which formed the Commission's

main hardwood holding and in which alone it seemed to be interested. It would appear that the Commission was so busy with the admittedly most important work of creating new forests that it omitted to take really active steps when it became evident that the subsidy alone was not producing results. The Commission has also been repeatedly and severely criticized for paying insufficient attention to the amenity aspects of forestry: much of this criticism has been based on ignorance and impatience, but by not taking it sufficiently seriously the Commission has lost many potential supporters, and has achieved a largely unnecessary unpopularity with quite large sections of the public.

Turning to the more technical aspects, the 30-year summary reveals other shortfalls in accomplishment, even where it appears to take credit for its achievements. The present urgent need for roads and buildings reflects lack of timely forethought which may well be linked with the general lag in organized forest management. This lag contrasts with the advanced plantation techniques that have been developed, but is in line with the inadequate consideration to integrated land use which also has been meeting with increasing public criticism. The considerable expansion of research activities of the last few years cannot obscure the fact that far too little was done over the first two decades, with the result that much needed information that can only be given by long-term studies, and might already have been obtained, is only now becoming available or is still lacking. Adequate seed-provenance studies and the reservation and special tending of selected seed stands are conspicuous examples of this. Even allowing for additional charges in the forests, 1½ per cent. of the total expenditure is quite inadequate for research in any case, and particularly for an enterprise which by its very nature calls for exceptional effort of this sort from the very start. Dissemination of existing knowledge has also been neglected, the list of publications, despite some excellent items, making a very poor showing for a 30-year period.

Next, the problems ahead, some of them the legacy of the past, some of them the foreseen consequences of normal development, may be briefly reviewed. Among the latter, the snowball accumulation of thinning work and utilization of very rapidly increasing amounts of small material must be one of the main occupations for the current decade. Problems of trained staff, labour, roadways, mechanization of extraction, industrial plant, are all involved—and the Commission is, rightly, giving them special attention. The acquisition of land is about to become a serious difficulty: it seems clear that the period of easy acquisition is ended and that a different approach will be necessary in future. The Commission will have to pay more attention to the wider problems of land use, and will probably have to be content with groups of moderate-sized blocks of forest rather than really big ones, despite the administrative and protective disadvantages.

The problem of the private woodlands is now being tackled in relation to the Dedication Scheme. The amount of controversy that has gone on about the scheme is itself an indication that the original proposals were based on an inadequate appreciation of the problems involved, due in part at least to absence of sufficient pioneer work in this field since 1919. If the scheme does not soon achieve a good measure of success in raising the production of the private woods, the Commission will have to think again; in the meantime, every reasonable suggestion needs to be tried out on a wide range of sites in the effort to solve the unquestionably difficult silvicultural and economic problems often involved. We cannot much longer go on accepting a figure of nearly half a million acres of devastated woods, with another quarter clear felled and not replanted.

So far the Commission has been fortunate in having been spared any major catastrophe in its large afforested blocks, 50 per cent. of them under spruce. We shall hope it may continue so, and there is not a great deal that can be done about it beyond being ready to cope

with epidemics or comparable troubles other countries have experienced. The best measures will probably prove to be a matter of silviculture and sound forest management.

The 40-year review should be even more interesting. We shall expect to see considerable changes in outlook, the management and utilization aspects of forestry taking precedence over those of afforestation technique.

Forest Products. By Nelson Courtlandt Brown. Chapman and Hall, 37 Essex Street, London, W.C. 2. Price 40*s*.

Review by C. P. Ackers

Forest Products by Nelson Courtlandt Brown should give to our forestry students a broader outlook on the future of timber and its uses than can be gathered from the normal text-book. To many of those interested in the conversion of the produce of British woodlands there also must be much of interest, for this book covers a very wide field.

In any work covering so very many aspects of the modern use of timber, nothing like a full account of any process of conversion can be given: the author fully acknowledges this. However, he has condensed in his work a very great deal of really interesting information concerning the main uses to which timber is now put. With processes changing so very rapidly, with so many new methods being employed, the up-to-date information given must be useful to many foresters and saw-millers in this country. Occasionally it may not be easy for us to follow, as, for example, the names by which we commonly know trees in this country are not given. I could find no mention of *Abies grandis*, but mention is made of the 'True Firs' used in the North Pacific lumber trade.

For very many years our trade has classed home-grown softwoods as larch and fir; the timber of any tree that was not larch was lumped in as just fir. Gradually a differentiation was made for Douglas fir. As, however, so little of the North American conifers still come to our home-grown timber trade and those that do come are so often coarse-branched park or specimen grown trees, little heed is still given to the quality of their timber. In America and Canada, where they grew in almost unlimited quantities, certain trees of real timber value were almost completely neglected by the lumbermen. An outstanding case of this was that of the neglect of the Western hemlock. Not so very long ago the value of the timber of any particular tree was its inherent value for the house-building and shipbuilding trades, and for agricultural machinery. Natural durability against wind and weather, natural strength in resisting strains and stresses gave, and still does give, the high value to oak for general purposes, ash and hickory pre-eminent for many purposes, Oregon pine for strength, Western red cedar for durability, and so on. These and others in a smaller way came into great prominence. In the last 50 years, and in many cases in the last few years only, Science and man's ingenuity have stepped in and radically made great changes in the uses to which the raw material of the world's forests can be put. Instead of the value of timber as timber, the emphasis now is so often on the value of the individual fibres of the timber of any species of tree, how they can be disintegrated and put together again; the value of other contents of timber such as lignin comes into the picture: the development in other ways, too, has of recent years been very great.

The study of Nelson Brown's recent book brings so much of this before us that, as foresters, our outlook on the future must surely tend to be 'bulk' picturing as important as 'quality'. Is a comparatively small crop of malting barley more in value than a heavy crop of feeding barley? Is a heavy crop of grandis or hemlock likely to be of more value than larch grown to boatskin quality or native pine grown to maturity?

Then we cannot help bringing into the picture the alarmingly increasing rate at which the human race is using up God's gifts to us in the form of coal and oil. The day must inevitably come when we must depend more and more on the vegetation grown on the earth's surface. Timber being a long rotation crop, it is the duty of foresters to look far further into the future than need the farmer. In his Preface Nelson Brown most rightly says: 'Wood seems destined to become the most important raw material of the future not only in the United States but also in many parts of Europe.'

We see in this book on forest products of the North American Continent many facts and figures to make us think deeply. Wood used as fuel is on the decrease, whereas with us it is very much on the increase. On the other hand, the use of Douglas fir as plywood has increased four-fold in the past 15 years: mines in the U.S.A. consume 232,000,000 cubic feet of timber annually and 7,500,000 cords of timber were used in 1929 in the pulp industry, as against 22,000,000 twenty years later, notwithstanding large importations from Canada: in 30 years rayon output has increased well over 100-fold. We see, too, the start that has been made in the use of fibreboards and plastics, the use of densified wood and of laminated structural members, uses probably all in their infancy at present.

We read interesting accounts of the great turpentine industry of the Southern States, the big industries of slack and tight cooperage, box and crate making, as well as the start that is being made in the possibility of extensive conversion of wood fibre to cattle food. We can read of a host of other smaller industries varying from athletic goods to Christmas trees, from Maple syrup and cascara to wood flour; all of interest. We can read, too, of the progress that is being made in silvicultural thinnings, under the rather strange headings of 'salvage' and 'sanitation', but less advanced than we are. But the main interest to us in Great Britain seems to be such things as the value of Western hemlock as a source of paper pulp, as a source of high-class interior house-building timber, as a source of high-quality plywood. If the growing of trees that give a great bulk of useful timber on either a short rotation or over a long rotation is of real importance, then should we not consider as foresters far more than we have in the past, the extensive planting of redwood, the giant fir (grandis), and the Western hemlock, as well as of Sitka and Douglas, trees we have widely planted? Should we not as timber merchants study more closely the value of the timber qualities of these trees and that of Lawson cypress and others? At present, and may it long continue, these trees suffer from no serious disease. Unfortunately they are in short supply and will continue to be until our Forestry Commissioners take more interest in them for the sake of the country's future timber resources. Should we not consider, too, the statement that their farm woodland lots have an annual output valued at £50,000,000?

Mr. Nelson Brown's book is profusely illustrated with excellent photographs, and it should have a good circulation among those in this country studying the building up or the exploitation of the produce of our woodlands.

Principles of Silviculture. By F. S. Baker. McGraw-Hill Publishing Co. Ltd. Aldwych House, London, W.C. 2, 1950, pp. 414, figs. 147, Tables 43. Price 42*s.* 6*d.*

Review by H. G. Champion

IT is one of the indications of the growth of knowledge in forestry and related fields that it is becoming impossible to cover in a single volume branches of the subject which were, till recently, normally so dealt with. Professor Baker's well-known *Theory and Practice of Silviculture*, expanded and developed to incorporate the results of subsequent experience and views since it was published in 1934, would make a tome too ponderous for convenient

use, and the volume under review is limited to a survey of the principles that underlie silvicultural practice, i.e. in American parlance, to *silvics*. Even so, the author has a difficult task in making the best selection from the mass of literature on the subject and in drawing the line in deciding how far he should go into matters that belong primarily to arboriculture or just botany, as distinguished from silvics. For example, coppicing is a silvicultural practice, and one might have expected to find an account of coppicing powers and what determines them; similarly, for regeneration by root-suckers, occlusion of wounds—a subject of specific importance in pruning and girdling—types of root system, and genetics. On some of these subjects, at least, passing reference and a finger-post to indicate where to look for further information would have been helpful to the student.

Similarly, it is not to be expected that all students in this field would agree as to the best balance in fullness of treatment of the different subjects discussed. Personally we would have liked to find more on the subject of water consumption or requirement, disagreeing with the author that the matter 'clearly has too little practical or scientific value to warrant detailed studies to clarify the matter', for it is a matter of prime importance over vast areas where moisture supplies are the limiting factor to growth and to land use generally. Reference might have been made to the work done in Java. On the question of mineral nutrients, it might have been pointed out that though, as a rule, marked consequences of deficiencies are rare, striking cases are on record, and it is more than likely that check in growth due to this cause commonly goes undetected, especially in afforestation of poor and difficult sites. Connected with this would be a reluctance in some of these same regions to agree that trees rarely root deeper than 4 feet. More on these matters would have been preferred to anatomical detail of the hypocotyl of conifers.

As the author himself puts it, there are static aspects of the subject—what the forest is—and dynamic—what the forest does, or how it works—to be dealt with, about four-fifths of the book being concerned with the latter. The first five chapters deal with the form and composition of forests, the classification into forest types on an ecological and statistical basis (site quality, density, and growing space), and after a fairly full discussion of tolerance the author goes on to deal successively with the physiological subjects of water relations, photosynthesis, nitrogen, and mineral nutrition. Next come chapters on seed production and dispersal, germination, mortality, and establishment, and the last quarter of the book is concerned with various aspects of growth. The treatment of these subjects is concise and clear. Authorities are quoted (519 of them!), but the author avoids the all-too-common tendency to quote uncritically, and lets readers see his opinion as to how each piece of information fits into the picture, or where it does not do so, he suggests possible reasons. The index could be fuller to advantage by inclusion of terms under which readers might be seeking information. The text is commendably free from typographical errors—we have noted none, though there is a curious slip in the footnote on p. 320, *betrieb* having slipped in where *trieb* was intended. A discrepancy may be noted between the text and the figure on p. 326, as Fig. 99 does not indicate maximum height growth with less than full sunlight, and only very doubtfully indicates a double maximum, but this is doubtless ascribable to over-condensation.

In conclusion, this is an excellent book which in many directions will prove most valuable to all workers and students in silviculture, not merely in North America, but in all countries.

Fifty Years of Forestry in the U.S.A. Edited by Robert K. Winters. Society of American Foresters, Washington 6, D.C. 4 dollars.

Review by W. M. McNeill

EDITORS are always on the look-out for anniversaries, and this mid-century milestone is providing a number of different kinds and descriptions. The forestry world is not without its share and, as the Society of Foresters of Great Britain prepares to celebrate the first 25 years of its existence, there appears this most interesting and absorbing book to mark the 50th anniversary of the founding of the Society of American Foresters and the 75th anniversary of the American Forestry Association.

It was a wise and appropriate decision on the part of the Society of American Foresters to produce an authoritative, comprehensive, and readable 'history of the growth of the profession in America' to celebrate these important dates. Wise, because as someone has said, 'we need to be reminded rather than instructed', and the story unfolded in this interesting book gives us an opportunity to appreciate the great work and achievement of American foresters. Appropriate, because the shape and form of forestry in America has, in no small way, been moulded by the zeal and vision of the professional Society of American Foresters.

The forest history of a country is part of the social history of that country and, quite apart from the professional value and the lessons which such a record teaches, the story of the growth and development of such a vast country as the United States during the last 50 years is as interesting as it is exciting. This is a book which every forester in this country can read with interest, delight, and profit and, indeed, which many not directly connected with the profession would do well to peruse. We are fortunate to have such a complete record of this aspect of American history, and the Society of American Foresters deserve both thanks and congratulations.

The book takes the form of a symposium of nineteen subject-chapters each contributed by a separate author. The headings include not only the professional or technical subjects such as 'Forest Protection', 'Silviculture', 'Forest Management', and 'Forest Utilization', but also the 'agencies and activities that have advanced professional forestry' as, for example, 'The U.S. Forest Service', 'The Society of American Foresters', 'Education in Professional Forestry', and 'Forest Research'. Recognized authorities in their respective subjects have been chosen to write each chapter and, while this inevitably produces a certain amount of unevenness and repetition, the general result is very satisfactory.

In his introductory chapter the editor refers to the story of the last fifty years of American forestry as a 'saga'. The *Oxford Dictionary* defines this word as 'a story of heroic achievement or adventure' and it is hardly an exaggeration to use it in this connexion. Certain figures stand out as giants and heroes in this remarkable record, men like Gifford Pinchot, Henry S. Graves, B. E. Fernow, and President Theodore Roosevelt. It is of special interest to read how deep and direct was the influence of Sir Dietrich Brandis on the shaping of the infant Forest Service in America, and 'it is notable that from the earliest times down to the present, interest in the conservation of [American] forests has been fostered largely by men of foreign birth or training' (p. 342).

The main impressions are of the hugeness of this undertaking, the drive and energy of the participants, and the truth of the proverb that 'Extremes meet'.

Examples are to be found in the great Peshtigo fire in Wisconsin in 1871, which 'took 1,500 lives . . . and burned 1·3 million acres of forest' (p. 2), the present 150 national forests totalling 180 million acres (p. 176), the annual out-turn of about 1,000 fully trained forestry

graduates (p. 28), the census 'of the nation's 631 million acres of forest land' (p. 182), 44·5 billion board feet cut in 1909 (p. 240), and so on.

The crusading spirit of the profession has been largely responsible for influencing national forestry policies and the passing of most important Acts of Congress. Unbelievable devastation and exploitation have been matched by stupendous conservation, fire protection, and rehabilitation schemes. Truly things are not done by halves in the U.S.A.! To single out some of the particularly interesting features of this period of development and achievement, mention must be made of the very large part played by the Society of American Foresters which 'now (1949) has a membership of 6,500' (p. 272). 'The objects of this Society shall be to represent, advance, and protect the interests and standards of the profession of forestry, and to provide a medium for the exchange of professional thought, and to promote the science, practice, and standards of forestry in America' (p. 274). It is interesting to compare these objects with those of our own Society of Foresters of Great Britain which is just half the age. In addition to the part this remarkable and virile professional society has taken in influencing legislative enactments, it has taken an active, and not always easy, part in establishing a high code of ethics in the profession, and it has performed an exceptional service in promoting a very high standard in forestry education. It has built up a worldwide reputation through its professional publication now so well known as *The Journal of Forestry*.

Readers in this country will be particularly interested in W. B. Greeley's excellent chapter on 'Industrial Forestry' which is full of the wisdom of experience and in 'Education in Professional Forestry' by such a well-known authority as Emeritus Professor Ralph S. Hosmer of Cornell University, and in 'Farm Forestry' by Joseph F. Kaylor. But it is difficult to single out subjects or authors in such an excellent and complete review of the last 50 years of American forestry, and all who want to know this remarkable story of achievement should certainly read this book.

NOTICES

Forestry Commission, *Cambial Injuries in a Pruned Stand of Norway Spruce*. By W. R. Day, Imperial Forestry Institute, Oxford. Forest Record Number 4. H.M.S. Office, 1950. Price 9*d*. 6½ in. × 8 in. unbound, punched for filing.

IT was arranged in 1947 that a number of representative stems from all treatments in a replicated pruning experiment at Drummond Hill Forest on Loch Tay-side, Perthshire, should be sent for investigation, partly by the Forest Products Research Laboratory, Princes Risborough, in connexion with the healing of wounds after pruning, and partly by the Imperial Forestry Institute at Oxford in respect of the diagnosis of the cause of the bark necrosis which had occurred so abundantly on many of the stems. This record is concerned with the origin of the bark necrosis, and the author's observations in his summary and conclusion are given below.

'A severe case of bark necrosis has occurred in Drummond Hill Forest, Perthshire, on Norway spruce treated experimentally by the removal at various times of the year of some of the lower live branches. The injuries are diagnosed as having arisen owing to frost damage which occurred usually after the pruning had taken place and either at the beginning or end of the growing season.

'Unpruned trees suffer from the same type of injury, but to a much less extent; though sometimes large areas of bark may die on such trees, especially at the base of the main stem.

'It is shown that the wood made by these spruce is abnormal in that its cell walls are of a weak structure and tend to be insufficiently lignified. This applies especially to the late wood, which in some years appears almost completely absent. It is also typical of these trees that the annual ring ends abnormally, indicating that their growing season is unduly long considering the type of climate in which they grow.

'The same type of injury occurs on Sitka spruce, and commonly the wood produced by this species is also of poor character. Japanese larch is also affected and one instance is known where it has suffered severely.

'The experimental demonstration of the diagnosis here put forward is under consideration; it does, however, involve some technical difficulties owing to the large size of the trees on which hitherto this type of bark injury has occurred. It is also considered desirable that research should be carried out into the relationship between provenance of spruce seed, the type of wood developed in Britain, and susceptibility to the type of injury here described. This is, indeed, a matter of some considerable importance, for the results of it might affect fundamentally the productive efficiency of future plantations. But it has already been demonstrated in other countries that the investigation of provenance, that is of the variability of a species and the relative usefulness of its variations in any particular region, is a matter well worthy of serious consideration.'

Forestry Commission, Booklet Number 3. *Chestnut Blight caused by the Fungus* Endothia Parasitica. H.M.S. Office, 1950. 2*s*. 6*d*.

THE purpose of the booklet is to describe with the aid of five coloured illustrations, prepared from paintings made in the Pathological Station of the Italian Ministry of Agriculture and Forests at Rome, the appearance of the disease now extensive in Italy so that familiarity with the symptoms may lead to rapid recognition should it ever reach

Great Britain. A distinction is drawn between the symptoms of *Endothia* and those of the fungus *Phytophthora cambivora* which is already destructive to chestnut grown on badly drained soils in some parts of Great Britain, and the booklet should be read by all concerned with chestnut cultivation or marketing.

Forestry Commission, *General Volume Tables for Oak, Beech, and Birch in Great Britain.* By F. C. Hummel and W. T. Waters (Forest Record Numbers 5, 6, and 7), and *General Volume Tables for Scots Pine, European Larch, and Norway Spruce in Great Britain*, by F. C. Hummel, T. W. Ervine, and J. Jeffers (Forest Record Numbers 8, 9, and 10). H.M.S. Office, 1950. Price 4*d*., 4*d*., 3*d*., 9*d*., 9*d*., and 1*s*. respectively. 6½ in. × 8 in. unbound, punched for filing.

THESE tables, prepared by the Forestry Commission Mensuration staff, form part of a series of forest records each giving average hoppus feet volume to one place of decimals for a full range of breast height quarter-girths by inches and quarter-inches for heights by feet for an important tree grown in Britain. Records for Corsican pine, Japanese larch, Sitka spruce, and Douglas fir are to follow.

Each record explains that the volume tables are intended to assist foresters, landowners, and others in estimating the cubic contents of standing timber and utters a warning that the volumes are average volumes and cannot therefore be relied on to give accurate contents of individual trees but only the aggregate volumes of groups or of whole stands. Suggestions for sampling are given and some figures also as a guide to the margins of error to be expected.

The three hardwood records are from measurements of felled trees and consist each of a single table giving volume to timber height (defined as top diameter 5 to 6 inches or to the point where the stem loses itself in the crown) in hoppus feet over bark for breast height quarter-girths of 6 inches to 30 inches for oak and beech and 6 inches to 18 inches for birch and for timber heights 10 feet to 50 feet for oak and beech and 10 feet to 40 feet for birch. Measurements were taken by 'stops', i.e. to points where there is a marked change. The tables for oak (1,521 trees) and beech (965 trees) are considered to give satisfactory estimates up to 30 feet timber height, but as most of the trees measured probably grew under open conditions, it is thought that for timber heights of over 30 feet in closed high forest the figures may be too low. The user is warned that figures for the longer timber lengths are based on too few figures and must be considered provisional. A distinction is made by printing these figures in italics.

The three conifer records are based on a larger number of measurements, i.e. Scots pine 5,677 trees, European larch 4,903 trees, and Norway spruce 2,617 trees. The material was obtained from:

1. Temporary sample plots established mainly between 1917 and 1919 for the purpose of preparing the provisional yield tables published in Forestry Commission Bulletin No. 3 (Forestry Commission 1920).
2. Measurements taken in the course of fellings during the first and second world wars by the timber supply departments, the Forestry Commission, and the University research parties.
3. The permanent sample plot records of the Forestry Commission.

All three sources were used for the general volume table which ranges from 2 inches to 27 inches (31 inches for Scots pine) breast height quarter-girth for lengths from 20 feet to 110 feet total height. Measurements are from ground level to a top diameter of 3 inches

over bark. In addition to the general volume table, there are eight other tables for which material was taken exclusively from the permanent sample plot records. Tables 2, 3, and 4 give volumes to top diameter 6, 9, and 12 inches respectively. Table 5 shows these volumes as percentages of the total volume to 3-inch top diameter. Tables 6, 7, and 8 give the average stem lengths to 3, 6, and 9 inches top diameter, while Table 9 gives bark percentages and an important appendix shows the number of trees used in each girth-height class in preparing the tables. The bark percentages for larch (nearly 20) seem high compared with Scots pine (15) and Norway spruce (10) and all are of course higher than the arbitrary figure fixed in the war-time control of felling order.

The estimation of volume in the Census of Woodlands of which a summary report has now been published (Forest Record Number 3, 1951, H.M.S. Office, 6*d*.) necessitated the preparation, in a relatively short time, of general volume tables for all the more common species of conifers and hardwoods and the publication of these Forest Records is a result. A certain amount of additional information about the preparation of these tables will be found in the chapter 'Studies of Growth' in the Forestry Commission *Report on Forest Research for the year ending March 1949* (H.M.S. Office, 1950, 1*s*. 9*d*. net.), where there is also a note on the increment of broadleaved species in Great Britain which, the report states, it is intended to publish as a separate record.

Sylva. The Annual Publication of the Edinburgh University Forestry Society. 1950–51. No. 31 Price 2*s*.

SYLVA maintains its high standard and this number contains contributions from several eminent foresters besides accounts from abroad and some good photographs. Soaring costs are causing some apprehension, but there is confidence, which will be shared everywhere, that this robust publication will surmount them.

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